

Figure 1. Schematic of conditional simulation process.

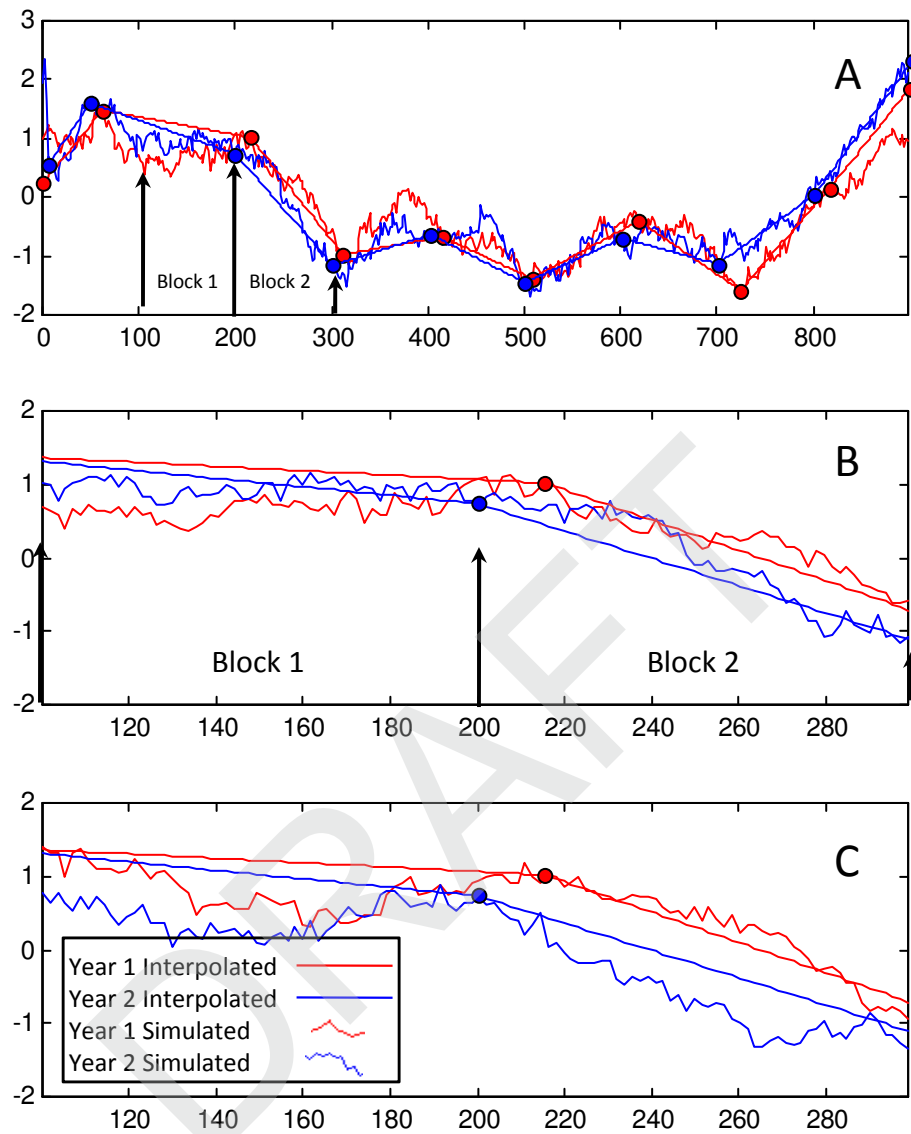


Figure 2. Illustration 1: Comparison of simulated and interpolated bathymetric elevations for a pair of equally likely realizations in panel (A). Panel (B) is an expanded view of the same pair as panel (A) and panel (C) is an alternative but equally likely pair from another random draw. Blocks 1 and 2 represent intervals over which mean elevation change is characterized.

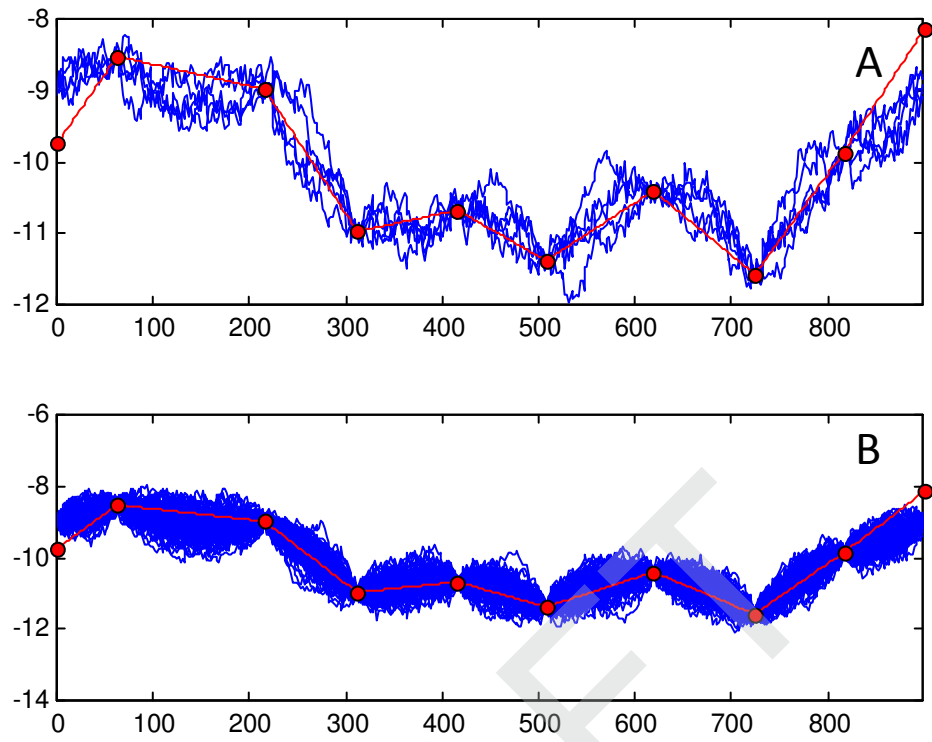


Figure 3. Illustration 1: Five equally likely simulated bathymetry surfaces (Panel A) and the ensemble of 1000 surfaces defining an envelope of uncertainty about the interpolated line (Panel B).

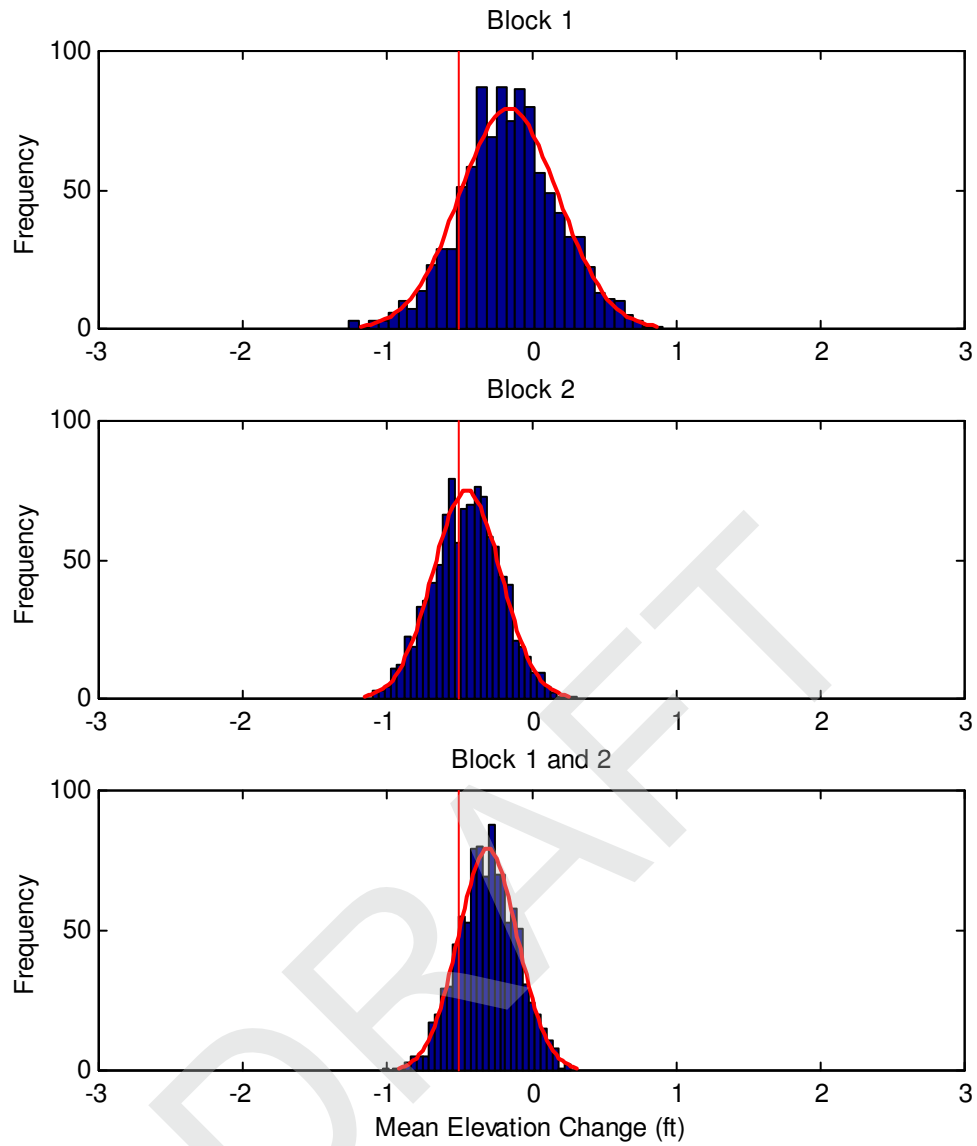


Figure 4. Illustration 1: Histogram of elevation change for blocks 1 and 2 and blocks 1 and 2 combined. The vertical line represents the 6 inch threshold used to define elevation changes distinguishable potential offsets due to measurement bias. Negative values represent erosion and positive values represent deposition.

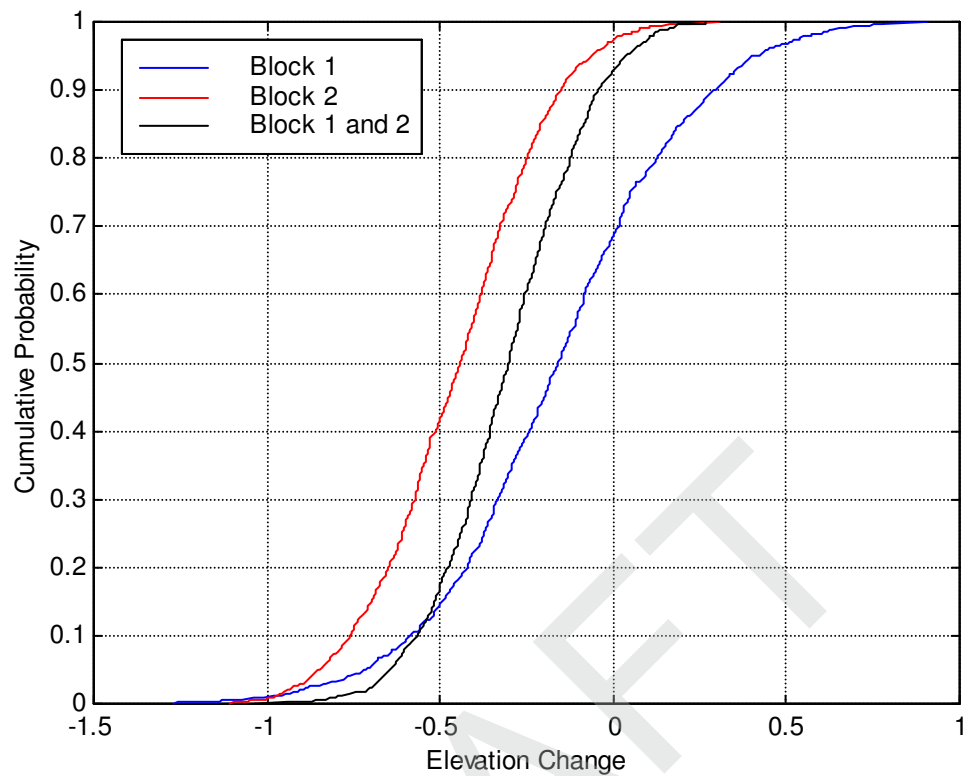


Figure 5. Illustration 1: Cumulative probability distribution for average elevation change fro blocks 1, 2 and block 1 and 2 combined. Probability of some erosion (i.e. negative change) is approximately 70%, 97% and 94% respectively for blocks 1, 2 and (1 and 2) combined. Yet the probability of more than 6 inches of erosion is less than 50% so these blocks would be classified as not erosional.

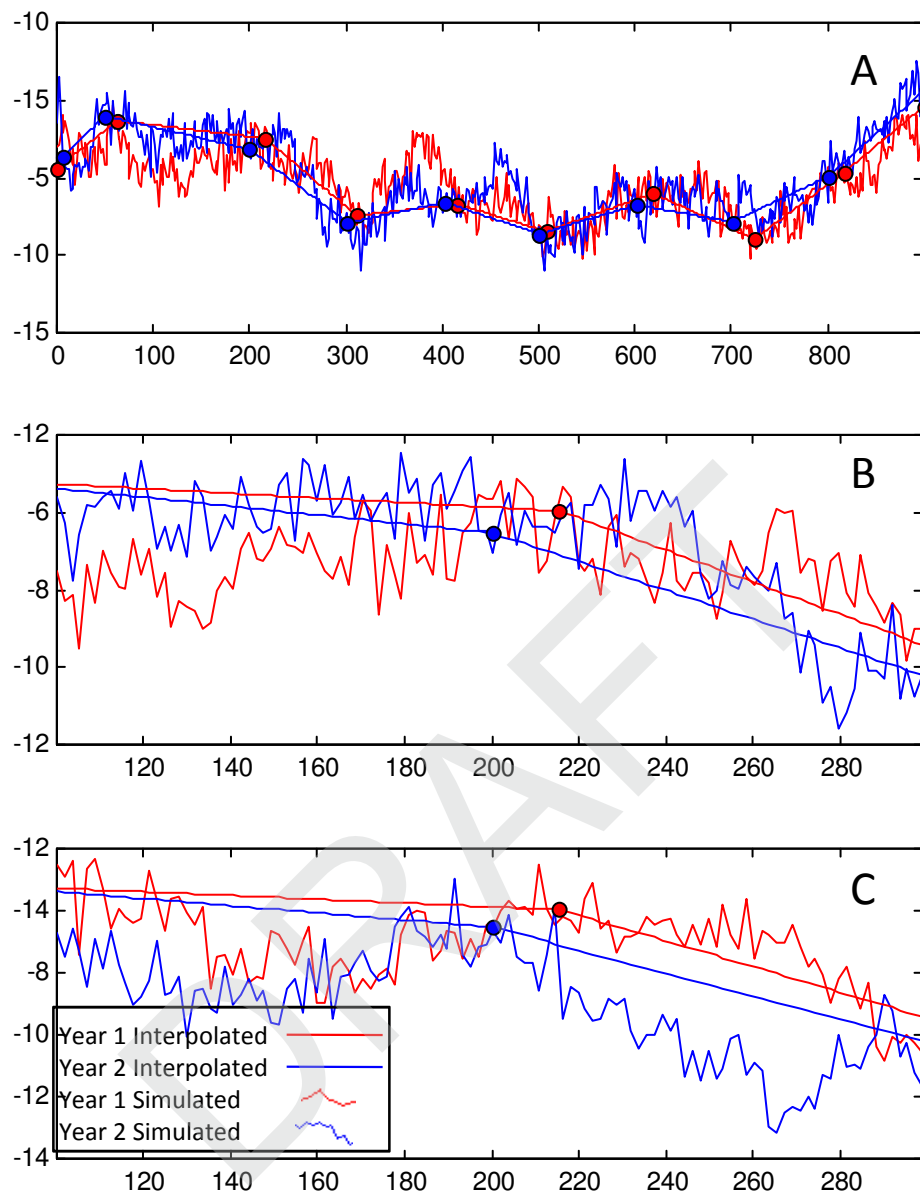


Figure 6. Illustration 2: Comparison of simulated and interpolated bathymetric elevations for a pair of equally likely realizations in panel (A). Panel (B) is an expanded view of the same pair as panel (A) and panel (C) is an alternative but equally likely pair from another random draw. Blocks 1 and 2 represent intervals over which mean elevation change is characterized.

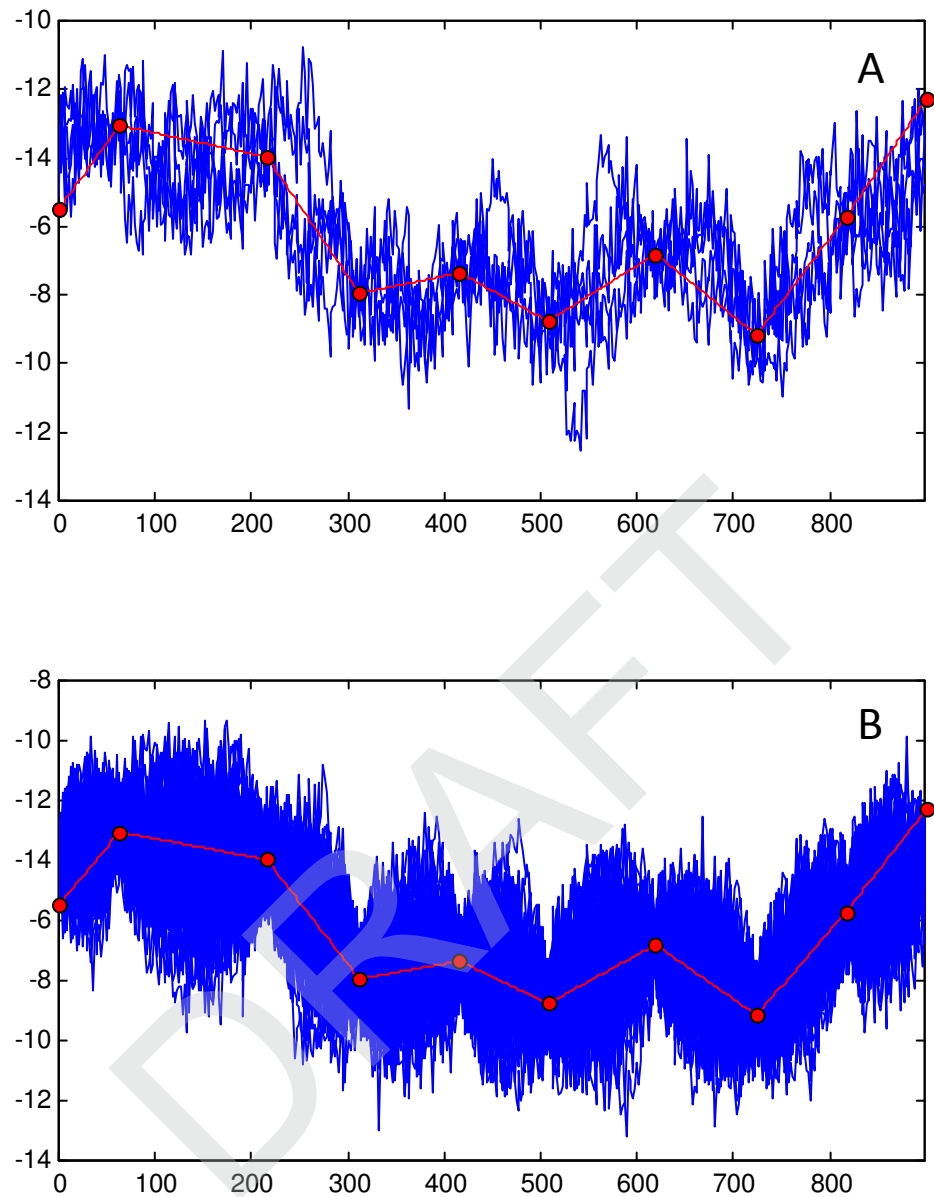


Figure 7. Illustration 2: Five equally likely simulated bathymetry surfaces (Panel A) and the ensemble of 1000 surfaces defining an envelope of uncertainty about the interpolated line (Panel B).

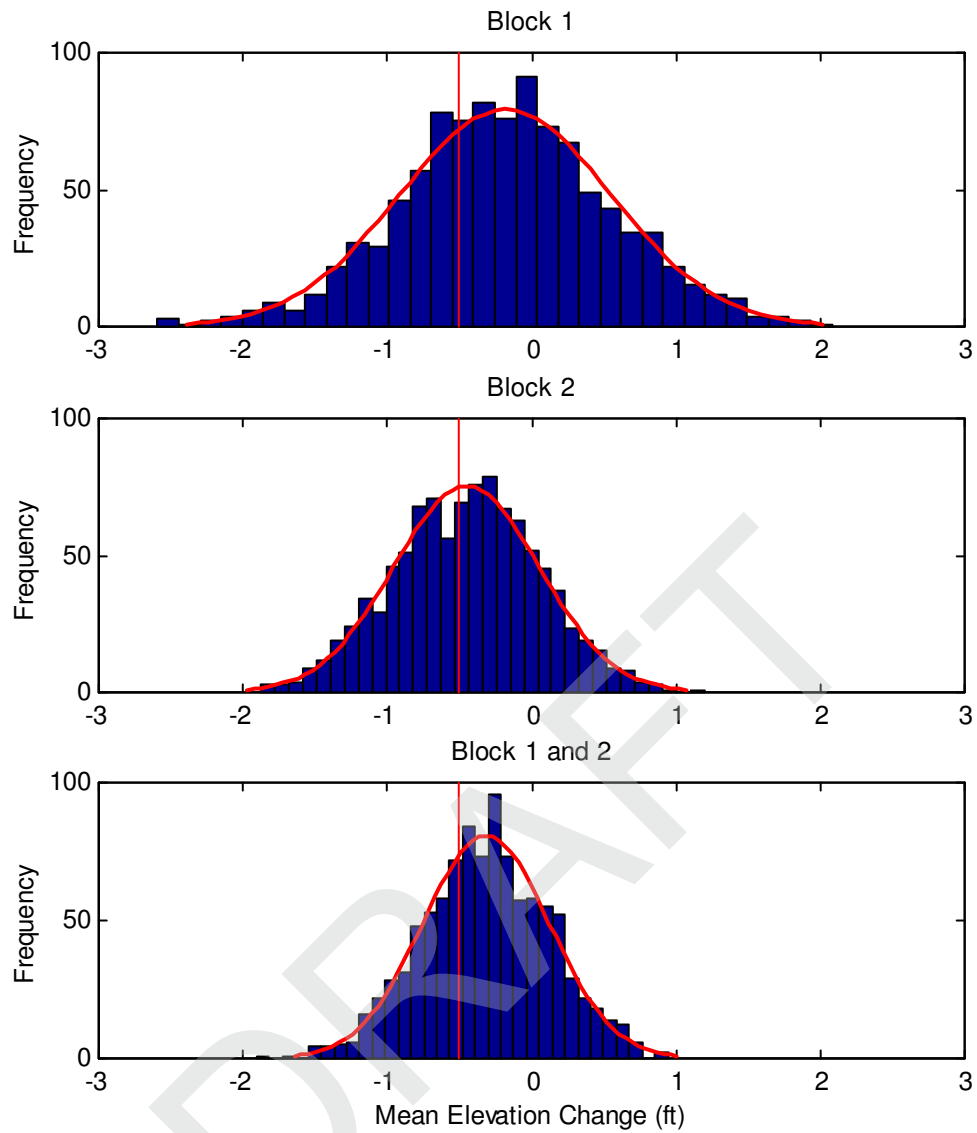


Figure 8. Illustration 2: Histogram of elevation change for blocks 1 and 2 and blocks 1 and 2 combined. The vertical line represents the 6 inch threshold used to define elevation changes distinguishable potential offsets due to measurement bias. Negative values represent erosion and positive values represent deposition.

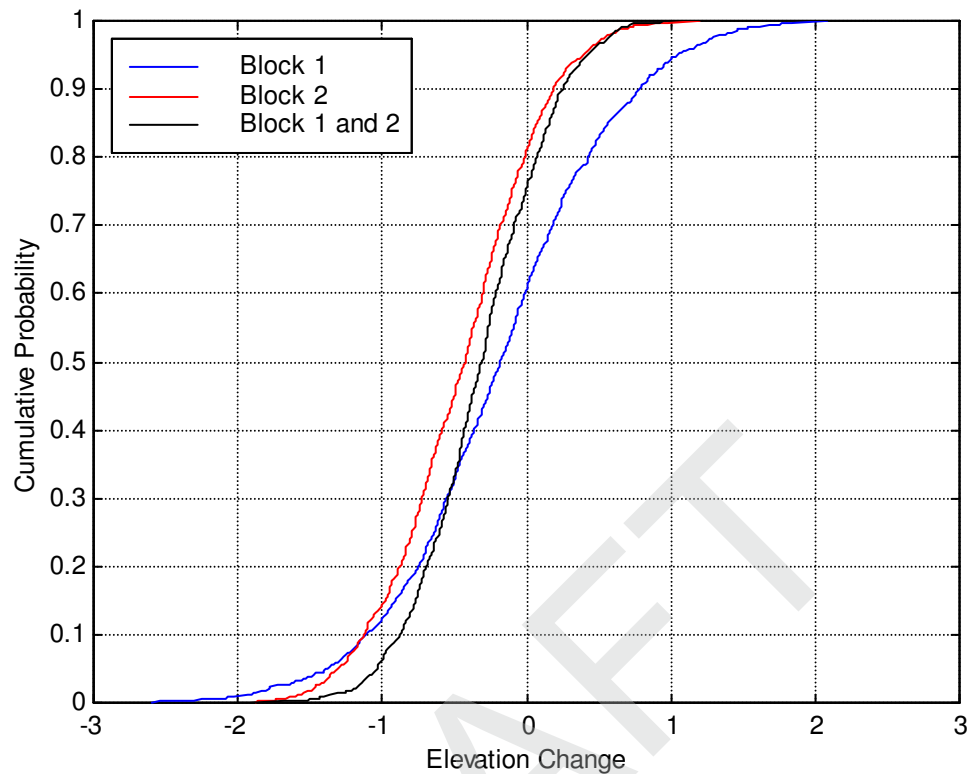
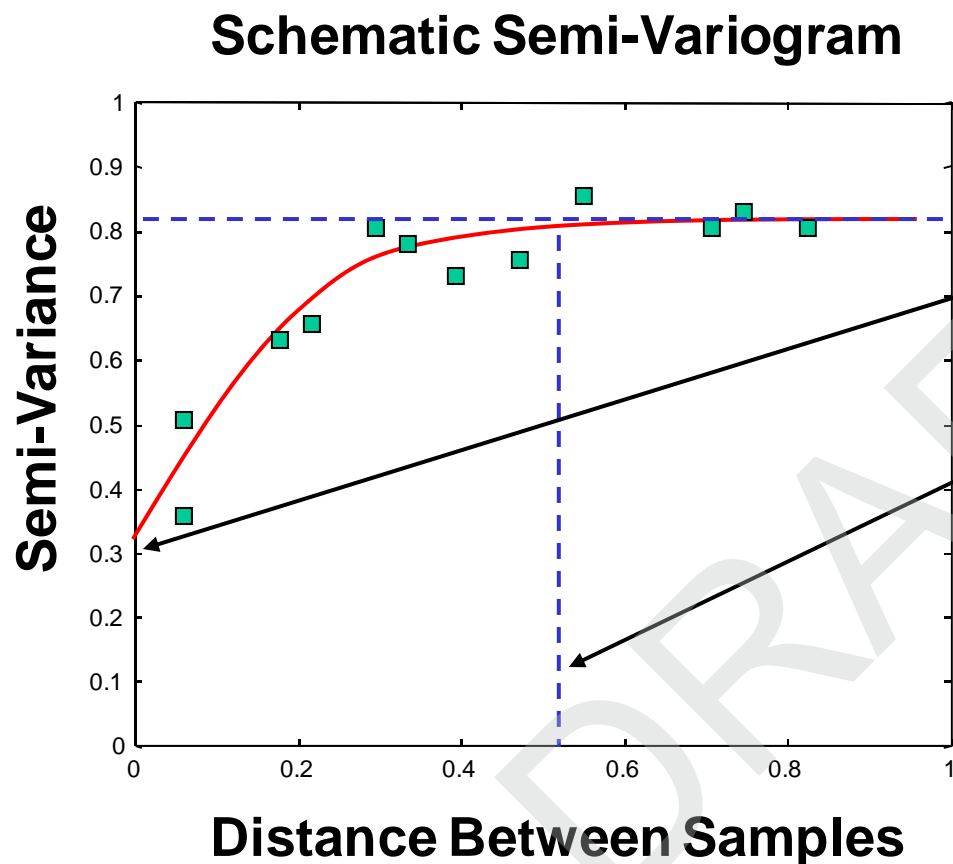


Figure 9. Illustration 2: Cumulative probability distribution for average elevation change from blocks 1, 2 and block 1 and 2 combined. Probability of some erosion (i.e. negative change) is approximately 60% to 80% respectively for blocks 1, 2 and (1 and 2) combined. Yet the probability of more than 6 inches of erosion is less than 50% so these blocks would be classified as not erosional.



Sill ~ Total variance among distant samples. For completely independent data this simplifies to sample variance S^2

Nugget Effect ~ Measure of small scale spatial heterogeneity.

Range of Influence ~ Distance at which samples are uncorrelated.

The semi-variogram is a measure of dissimilarity:

$$\text{Average } \frac{(V_i - V_j)^2}{2}$$

$$\text{Spatial Correlation} = 1 - (\text{Semi-Variogram})/\sigma^2$$

Figure 10. Schematic semi-variogram with definitions parameters.

Figure 11: Long flow and cross flow coordinate axes resulting from the Schwartz-Christoffel conformal mapping in a selected part of the lower Passaic River.

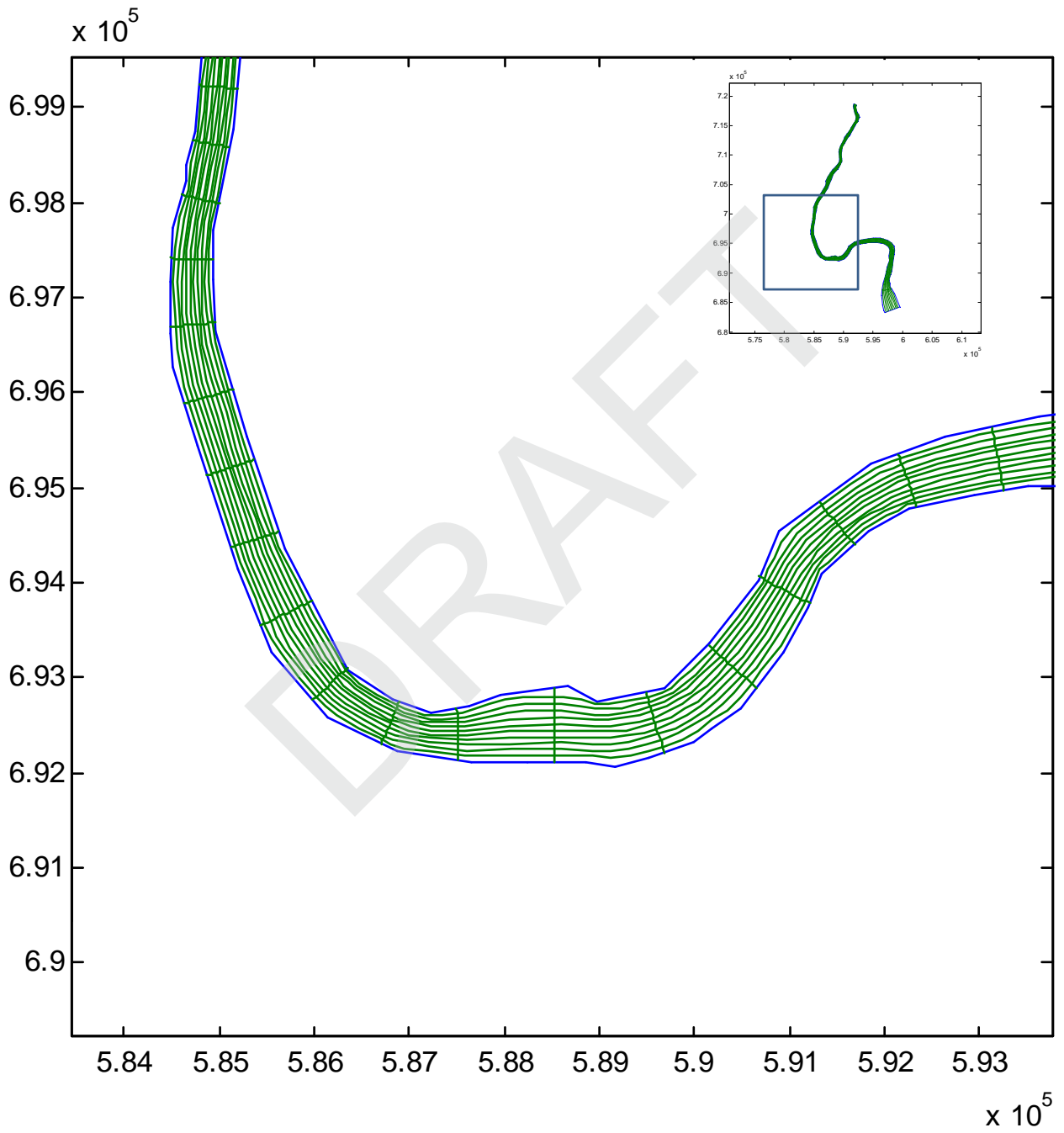


Figure 12a. Histogram and Summary Statistics for 1989 Bathymetry Survey

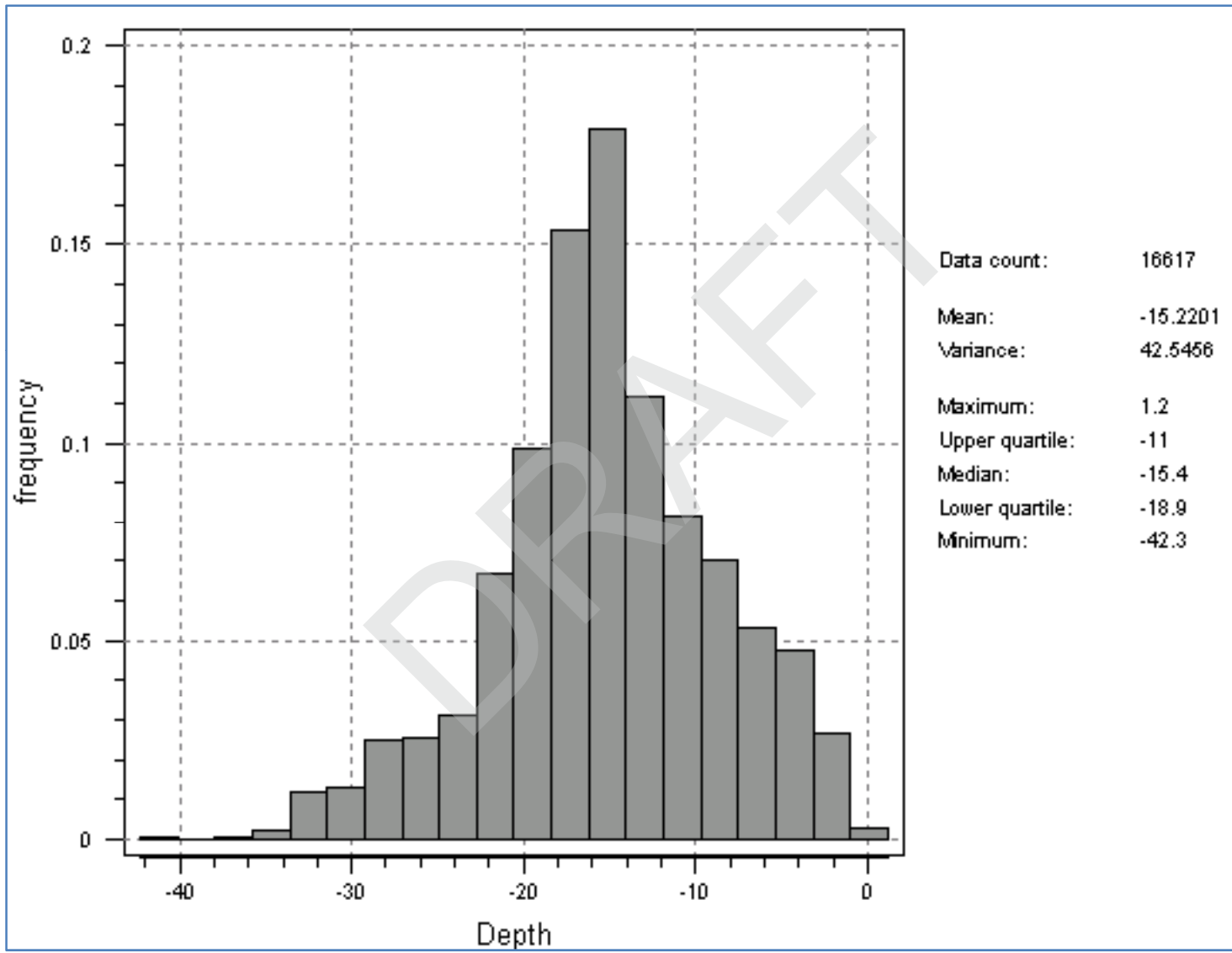


Figure 12b. Histogram and Summary Statistics for 1995 Bathymetry Survey

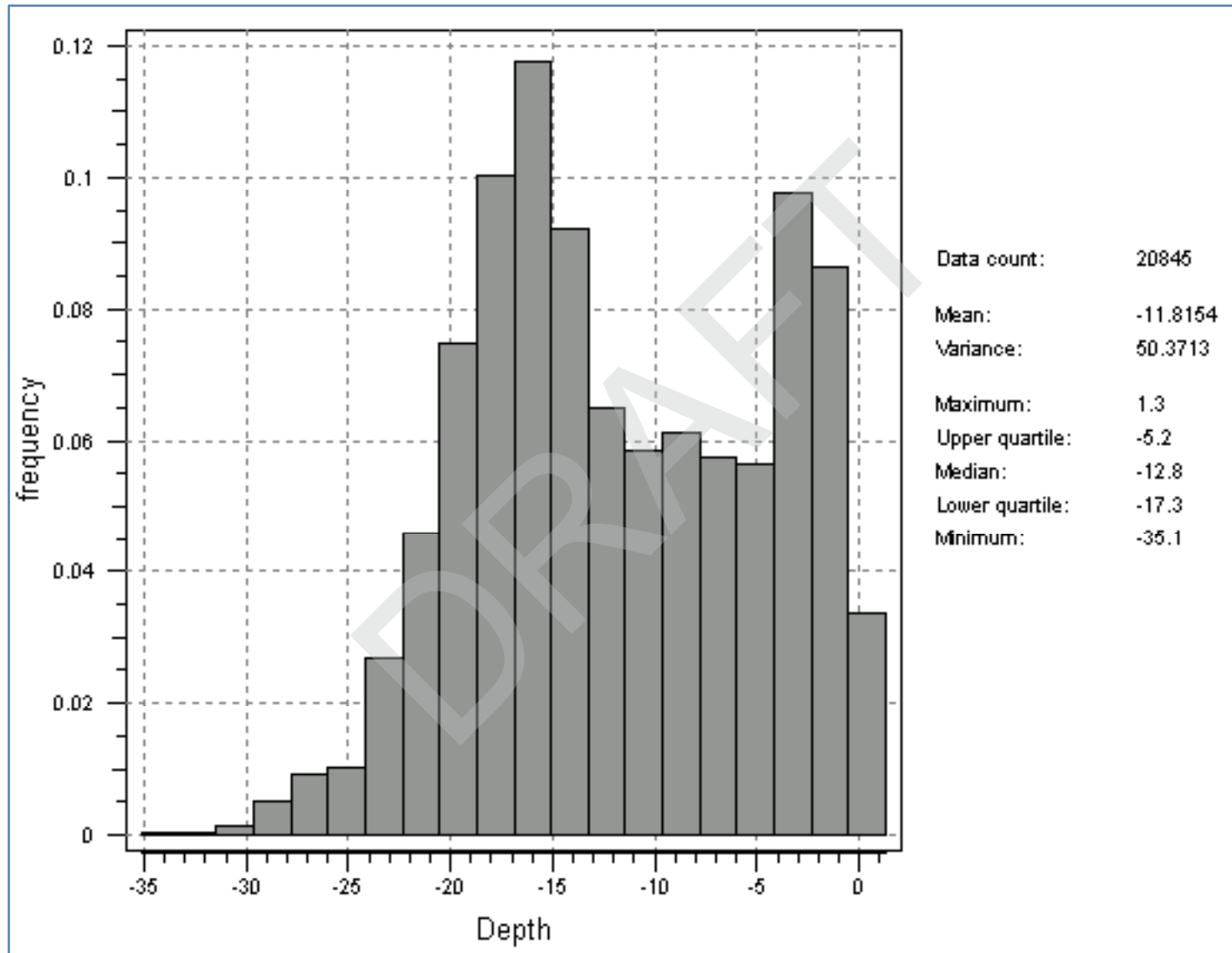


Figure 12c. Histogram and Summary Statistics for 1996 Bathymetry Survey

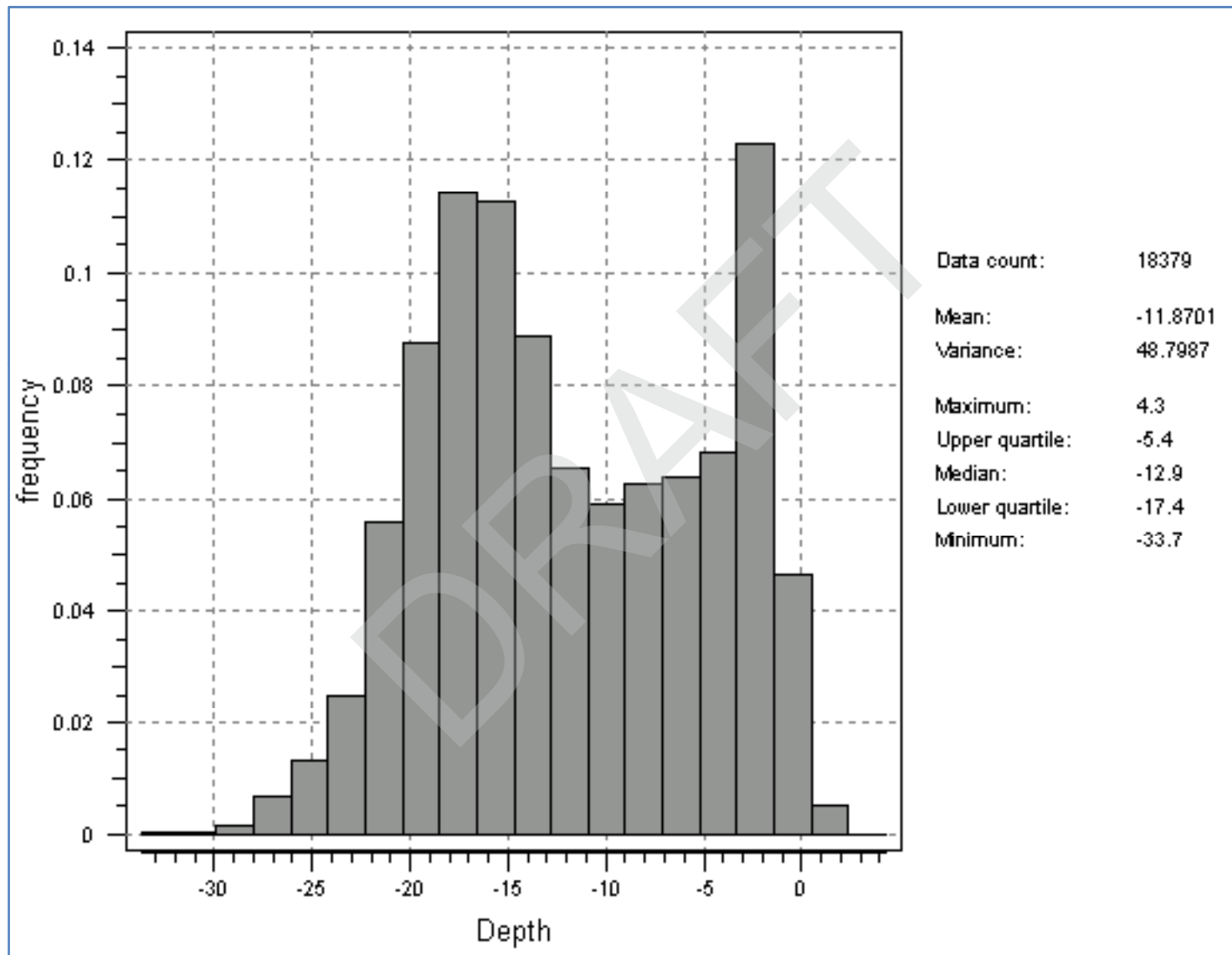


Figure 12d. Histogram and Summary Statistics for 1997 Bathymetry Survey

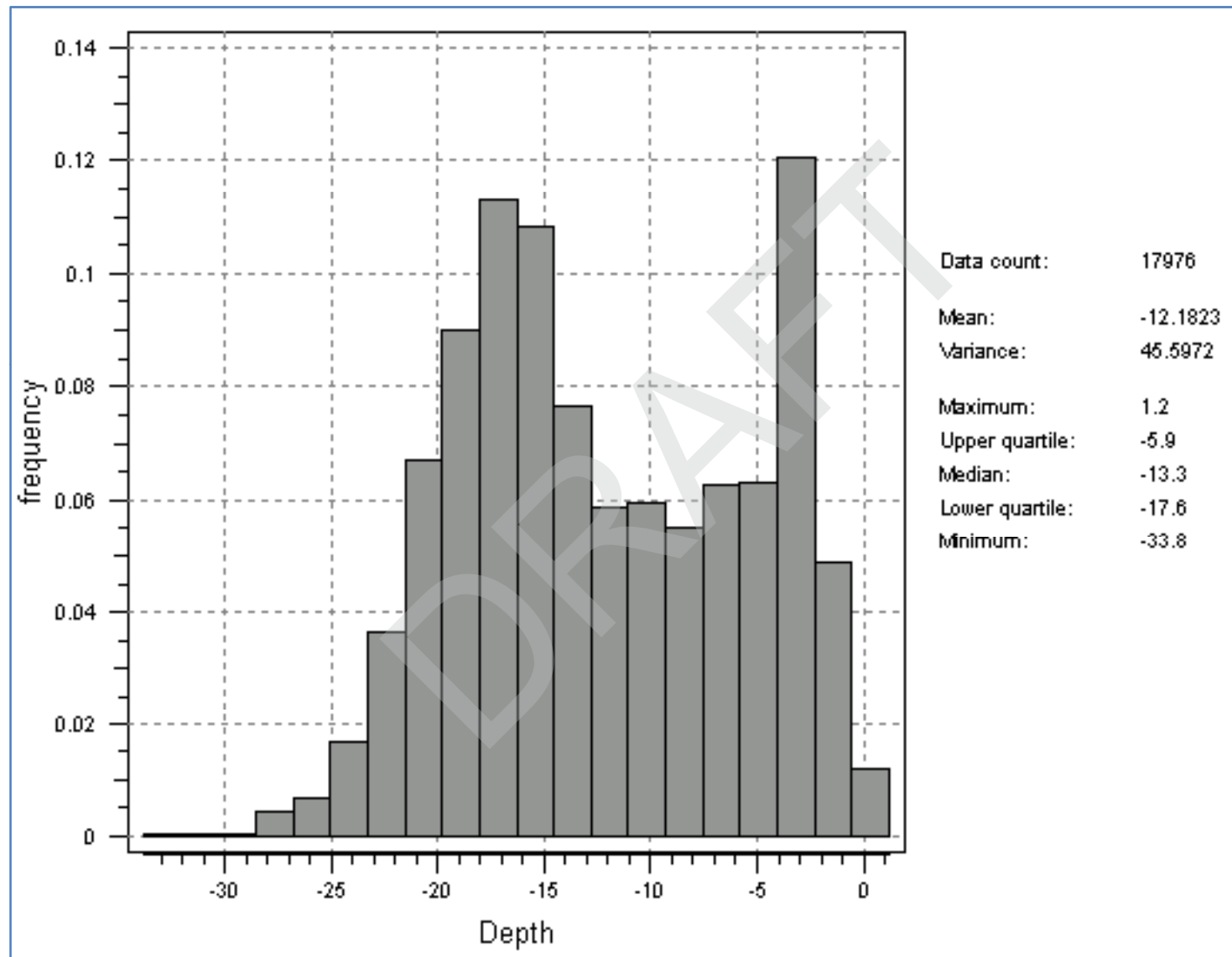


Figure 12e. Histogram and Summary Statistics for 1999 Bathymetry Survey

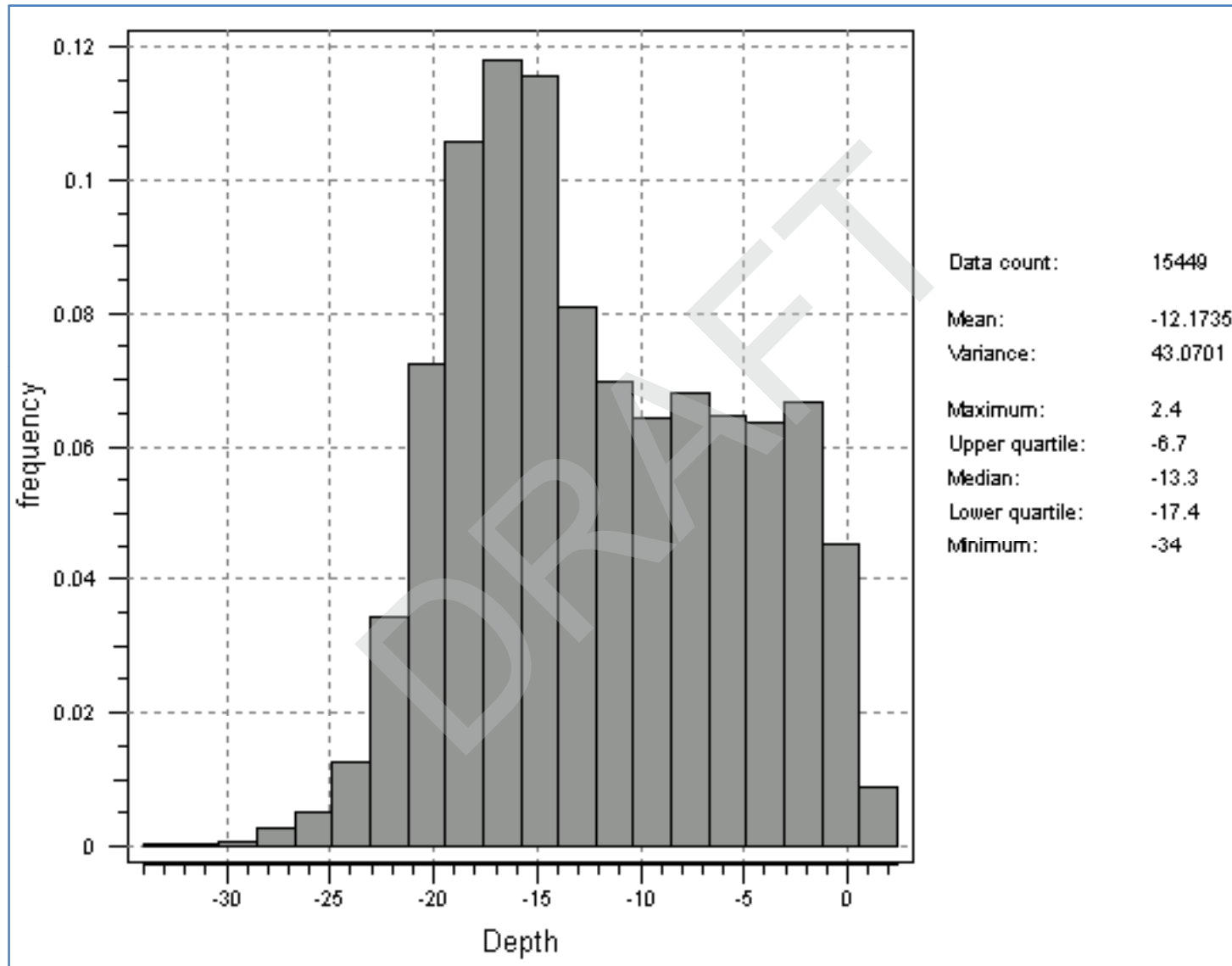


Figure 12f. Histogram and Summary Statistics for 2001 Bathymetry Survey

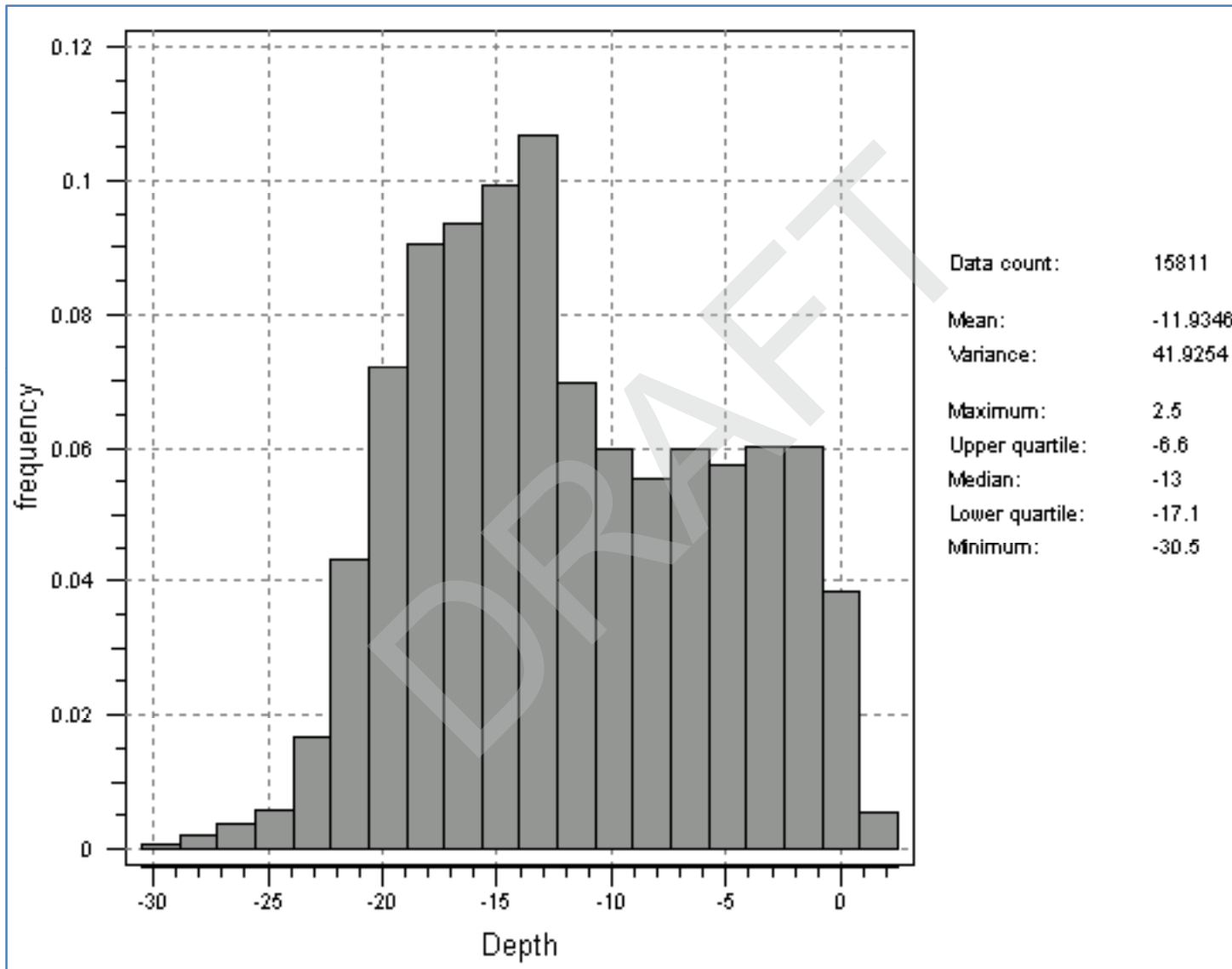


Figure 12g. Histogram and Summary Statistics for 2002 Bathymetry Survey

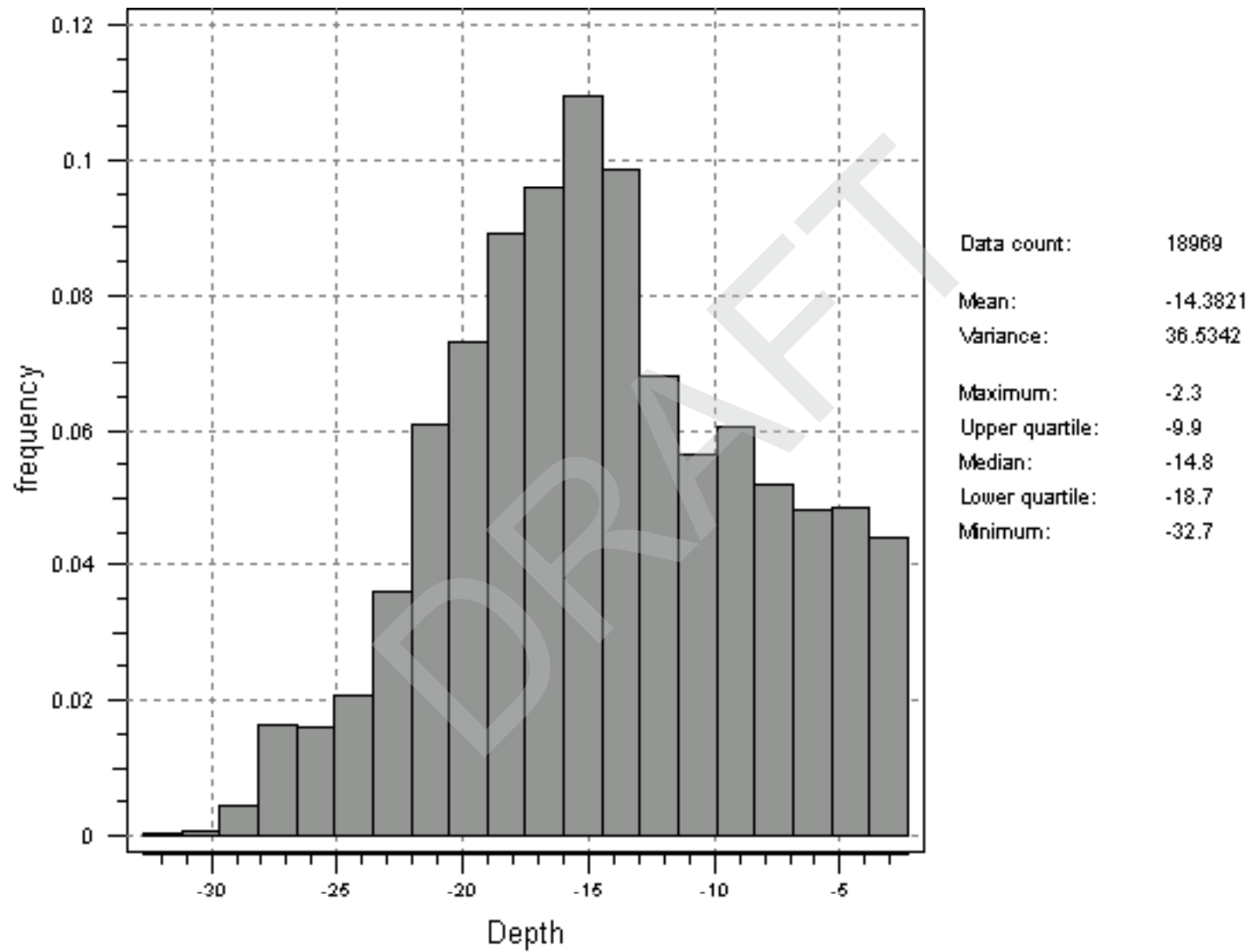


Figure 12h. Histogram and Summary Statistics for 2004 Bathymetry Survey

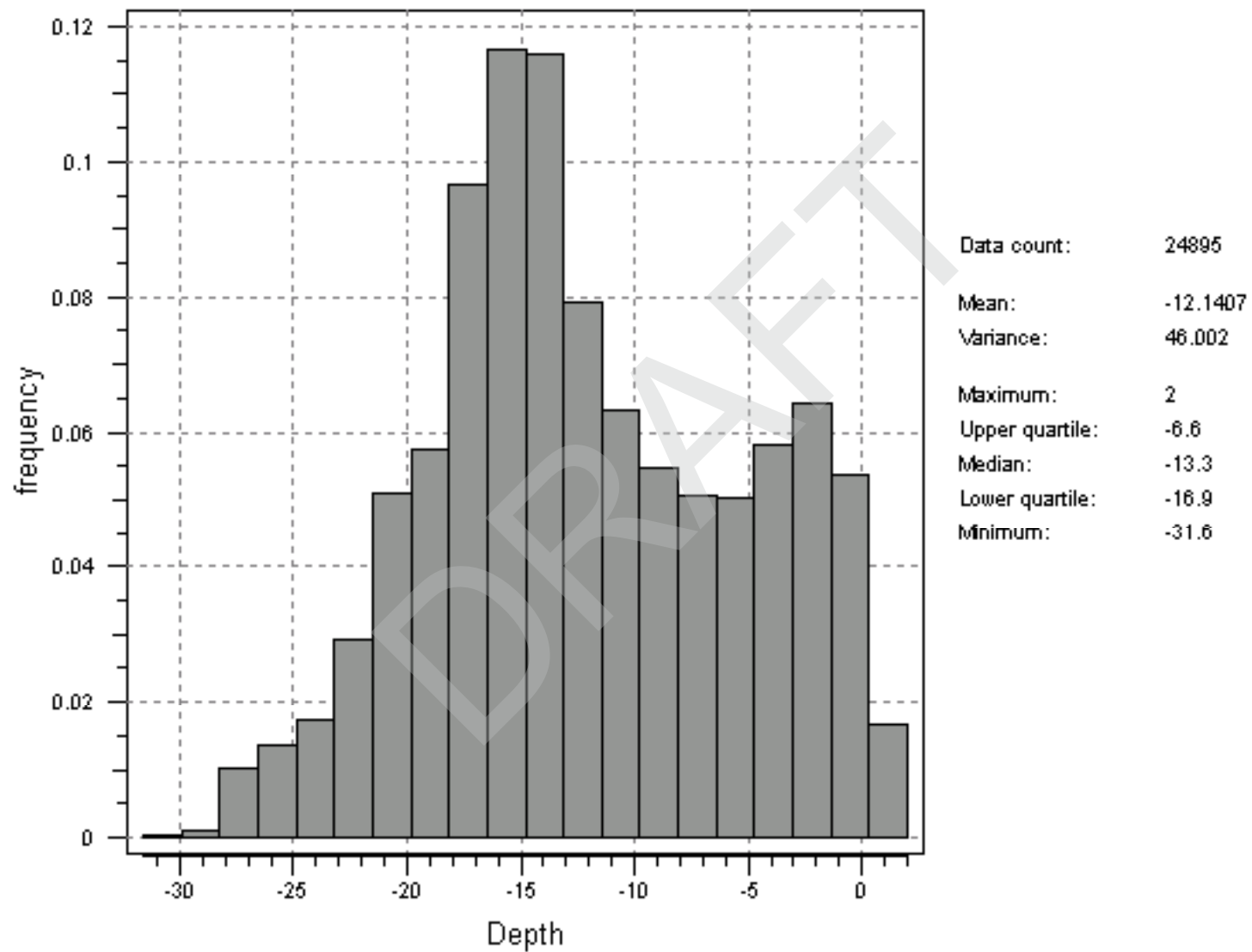


Figure 12i: Polynomial Regression Result for 1989 bathymetry

Multiple Regression Analysis for 1989 Bathymetry Survey Depth and Transformed River Coordinates
(Note: U = Cross Flow Coordinate; V = Along Flow Coordinate)

Dependent variable: Depth

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-14.62280	0.236888	-61.729	0.0000
U	2.47516	0.215729	11.474	0.0000
V	0.03028	0.002888	10.484	0.0000
U*U	0.90473	0.112363	8.052	0.0000
V*V	-0.00015	0.000008	-17.603	0.0000
U*V	-0.01657	0.000966	-17.152	0.0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	95633.4	5	19126.7	519.73	0.0000
Residual	611305.0	16611	36.8012		
Total (Corr.)	706938.0	16616			

R-squared = 13.5278 percent

R-squared (adjusted for d.f.) = 13.5018 percent

Standard Error of Est. = 6.0664

Mean absolute error = 4.79136

Durbin-Watson statistic = 0.130868 (P=0.0000)

Lag 1 residual autocorrelation = 0.9345

Figure 12j: Polynomial Regression Result for 1995 bathymetry. Inset Figure is Semivariogram of Residuals

Multiple Regression Analysis for 1995 Bathymetry Survey Depth and Transformed River Coordinates
(Note: U = Cross Flow Coordinate; V = Along Flow Coordinate)

Dependent variable: Depth

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-6.01978	0.474852	-12.6772	0.0000
U	-1.09495	0.228131	-4.7997	0.0000
V	-0.08985	0.005290	-16.9857	0.0000
U*U	5.32106	0.091953	57.8671	0.0000
V*V	0.00022	0.000014	15.9645	0.0000
U*V	-0.00474	0.001005	-4.7121	0.0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	181699.0	5	36339.8	872.21	0.0000
Residual	868240.0	20839	41.6642		

Total (Corr.) 1.04994E6 20844

R-squared = 17.3057 percent
R-squared (adjusted for d.f.) = 17.2858 percent
Standard Error of Est. = 6.45478
Mean absolute error = 5.33981
Durbin-Watson statistic = 0.0296894 (P=0.0000)
Lag 1 residual autocorrelation = 0.985152

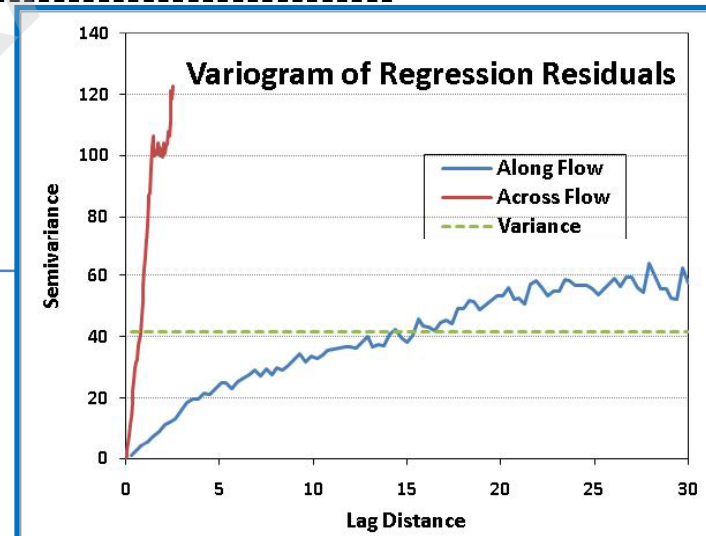


Figure 12k: Polynomial Regression Result for 1996 bathymetry

Multiple Regression Analysis for 1996 Bathymetry Survey Depth and Transformed River Coordinates
 Note: U = Cross Flow Coordinate; V = Along Flow Coordinate)

Dependent variable: Depth

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-16.90500	0.899662	-18.7904	0.0000
U	-0.36220	0.318288	-1.1380	0.2551
V	0.00854	0.008793	0.9716	0.3313
U*U	5.16838	0.095408	54.1717	0.0000
V*V	0.00001	0.000021	0.4037	0.6864
U*V	-0.00683	0.001346	-5.0771	0.0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	149683.0	5	29936.6	736.17	0.0000
Residual	747140.0	18373	40.6651		
Total (Corr.)	896823.0	18378			

R-squared = 16.6904 percent

R-squared (adjusted for d.f.) = 16.6677 percent

Standard Error of Est. = 6.37692

Mean absolute error = 5.26645

Durbin-Watson statistic = 1.95342 (P=0.0008)

Lag 1 residual autocorrelation = 0.0232867

Figure 12I: Polynomial Regression Result for 1997 bathymetry

Multiple Regression Analysis for 1997 Bathymetry Survey Depth and Transformed River Coordinates
(Note: U = Cross Flow Coordinate; V = Along Flow Coordinate)

Dependent variable: Depth

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-15.43800	0.889624	-17.3534	0.0000
U	0.41462	0.327394	1.2664	0.2054
V	-0.00962	0.008684	-1.1077	0.2680
U*U	4.62971	0.098426	47.0377	0.0000
V*V	0.00006	0.000020	2.8574	0.0043
U*V	-0.00960	0.001377	-6.9715	0.0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	122616.0	5	24523.2	632.26	0.0000
Residual	696994.0	17970	38.7865		
Total (Corr.)	819610.0	17975			

R-squared = 14.9603 percent

R-squared (adjusted for d.f.) = 14.9366 percent

Standard Error of Est. = 6.22788

Mean absolute error = 5.1599

Durbin-Watson statistic = 1.46572 (P=0.0000)

Lag 1 residual autocorrelation = 0.267112

Figure 12m: Polynomial Regression Result for 1999 bathymetry

Multiple Regression Analysis for 1999 Bathymetry Survey Depth and Transformed River Coordinates
(Note: U = Cross Flow Coordinate; V = Along Flow Coordinate)

Dependent variable: Depth

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-23.76950	0.87765	-27.0832	0.0000
U	-9.85349	0.31098	-31.6848	0.0000
V	0.08111	0.00884	9.1712	0.0000
U*U	7.05628	0.09114	77.4202	0.0000
V*V	-0.00019	0.00002	-8.9664	0.0000
U*V	0.04073	0.00137	29.702	0.0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	193813.0	5	38762.6	1269.50	0.0000
Residual	471533.0	15443	30.5338		
Total (Corr.)	665346.0	15448			

R-squared = 29.1296 percent

R-squared (adjusted for d.f.) = 29.1067 percent

Standard Error of Est. = 5.52574

Mean absolute error = 4.52886

Durbin-Watson statistic = 1.59393 (P=0.0000)

Lag 1 residual autocorrelation = 0.202988

Figure 12n: Polynomial Regression Result for 2001 bathymetry

Multiple Regression Analysis for 2001 Bathymetry Survey Depth and Transformed River Coordinates
(Note: U = Cross Flow Coordinate; V = Along Flow Coordinate)

Dependent variable: Depth

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-26.8546	0.86168	-31.1653	0.0000
U	-10.7103	0.30563	-35.0432	0.0000
V	0.1128	0.00868	12.9854	0.0000
U*U	6.7680	0.08866	76.3319	0.0000
V*V	-0.0003	0.00002	-12.4402	0.0000
U*V	0.0447	0.00134	33.2957	0.0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	194485.0	5	38896.9	1312.61	0.0000
Residual	468355.0	15805	29.6334		
Total (Corr.)	662840.0	15810			

R-squared = 29.3411 percent

R-squared (adjusted for d.f.) = 29.3188 percent

Standard Error of Est. = 5.44365

Mean absolute error = 4.47725

Durbin-Watson statistic = 1.59144 (P=0.0000)

Lag 1 residual autocorrelation = 0.204263

Figure 12o: Polynomial Regression Result for 2002 bathymetry

Multiple Regression Analysis for 2002 Bathymetry Survey Depth and Transformed River Coordinates
(Note: U = Cross Flow Coordinate; V = Along Flow Coordinate)

Dependent variable: Depth

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-15.1029	0.481731	-31.3513	0.0000
U	2.3383	0.233236	10.0253	0.0000
V	0.0291	0.005260	5.5312	0.0000
U*U	1.1821	0.094716	12.4807	0.0000
V*V	-0.0001	0.000013	-8.4951	0.0000
U*V	-0.0176	0.001022	-17.2185	0.0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	65099.7	5	13019.9	393.22	0.0000
Residual	627880.0	18963	33.1108		
Total (Corr.)	692980.0	18968			

R-squared = 9.39416 percent

R-squared (adjusted for d.f.) = 9.37027 percent

Standard Error of Est. = 5.7542

Mean absolute error = 4.7017

Durbin-Watson statistic = 0.0507036 (P=0.0000)

Lag 1 residual autocorrelation = 0.974557

Figure 12p: Polynomial Regression Result for 2004 bathymetry

Multiple Regression Analysis for 2004 Bathymetry Survey Depth and Transformed River Coordinates
(Note: U = Cross Flow Coordinate; V = Along Flow Coordinate)

Dependent variable: Depth

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-13.6587	0.164017	-83.2761	0.0000
U	-1.95215	0.136465	-14.3052	0.0000
V	0.03363	0.002168	15.5093	0.0000
U*U	4.23460	0.076119	55.6312	0.0000
V*V	-0.00016	0.000007	-24.7688	0.0000
U*V	-0.00185	0.000639	-2.8930	0.0038

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	207735.0	5	41546.9	1103.07	0.0000
Residual	937440.0	24889	37.6648		
Total (Corr.)	1.14517E6	24894			

R-squared = 18.14 percent

R-squared (adjusted for d.f.) = 18.1236 percent

Standard Error of Est. = 6.13717

Mean absolute error = 5.03368

Durbin-Watson statistic = 0.0500437 (P=0.0000)

Lag 1 residual autocorrelation = 0.974926

Figure 13: Estimated trend surface for 1995 bathymetry elevations. Note that the long- and cross-flow coordinates are not to scale or proportion.

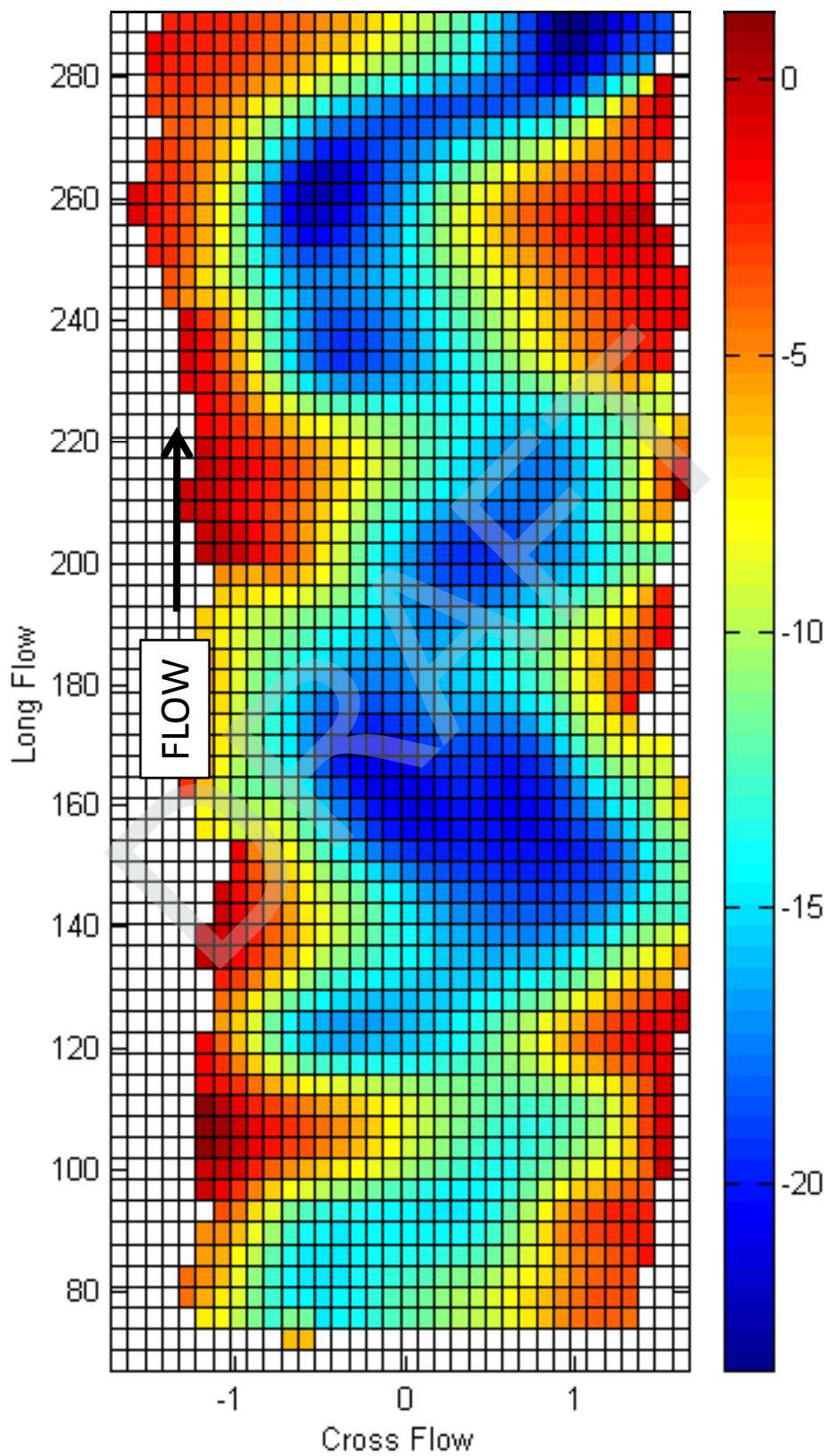


Figure 14a: Directional Semivariograms and Fitted Models for Normal Scores Transformed Residuals of Detrended 1989 Bathymetry

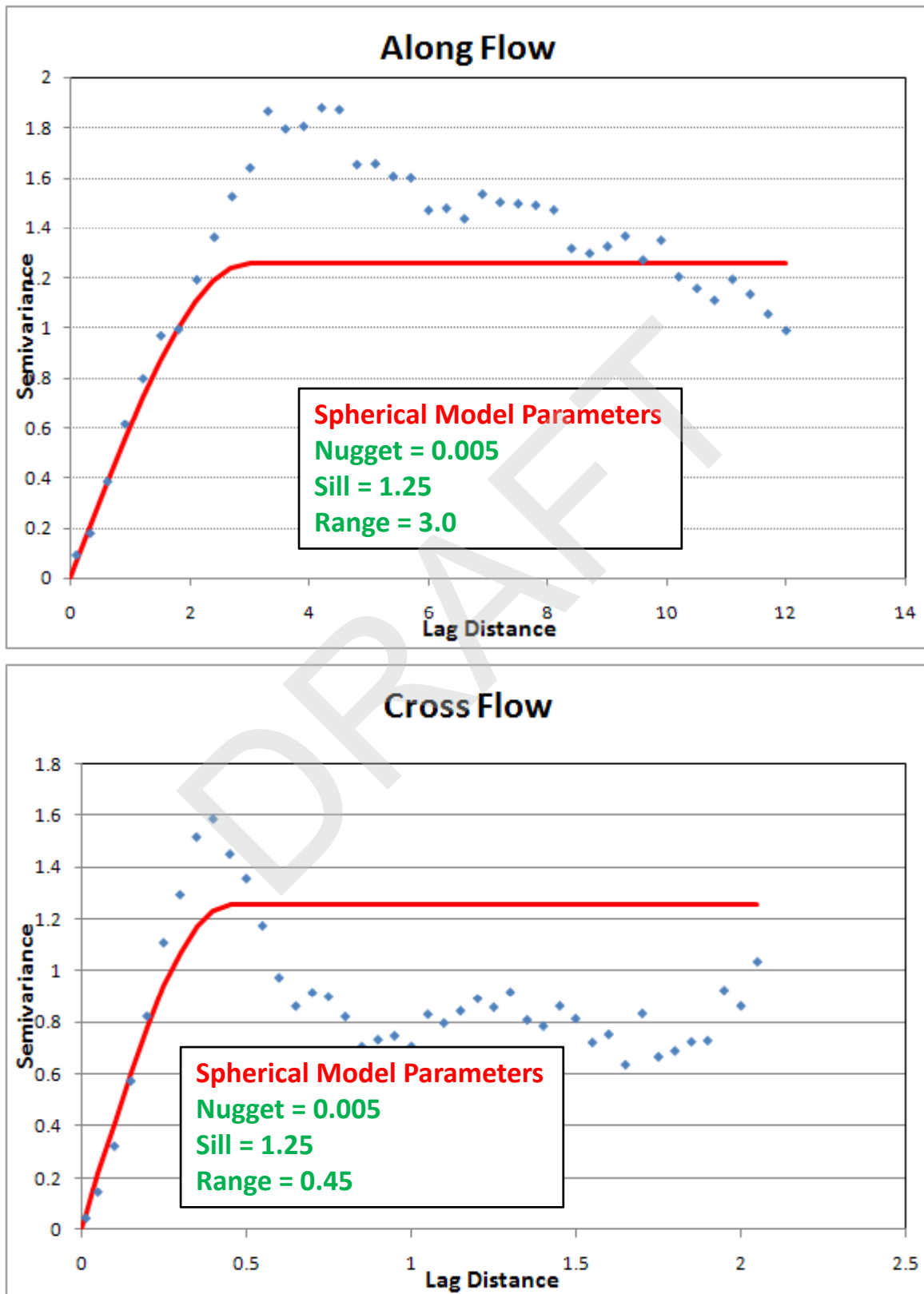


Figure 14b: Directional Semivariograms and Fitted Models for Uniform Scores Transformed Residuals of Detrended 1989 Bathymetry

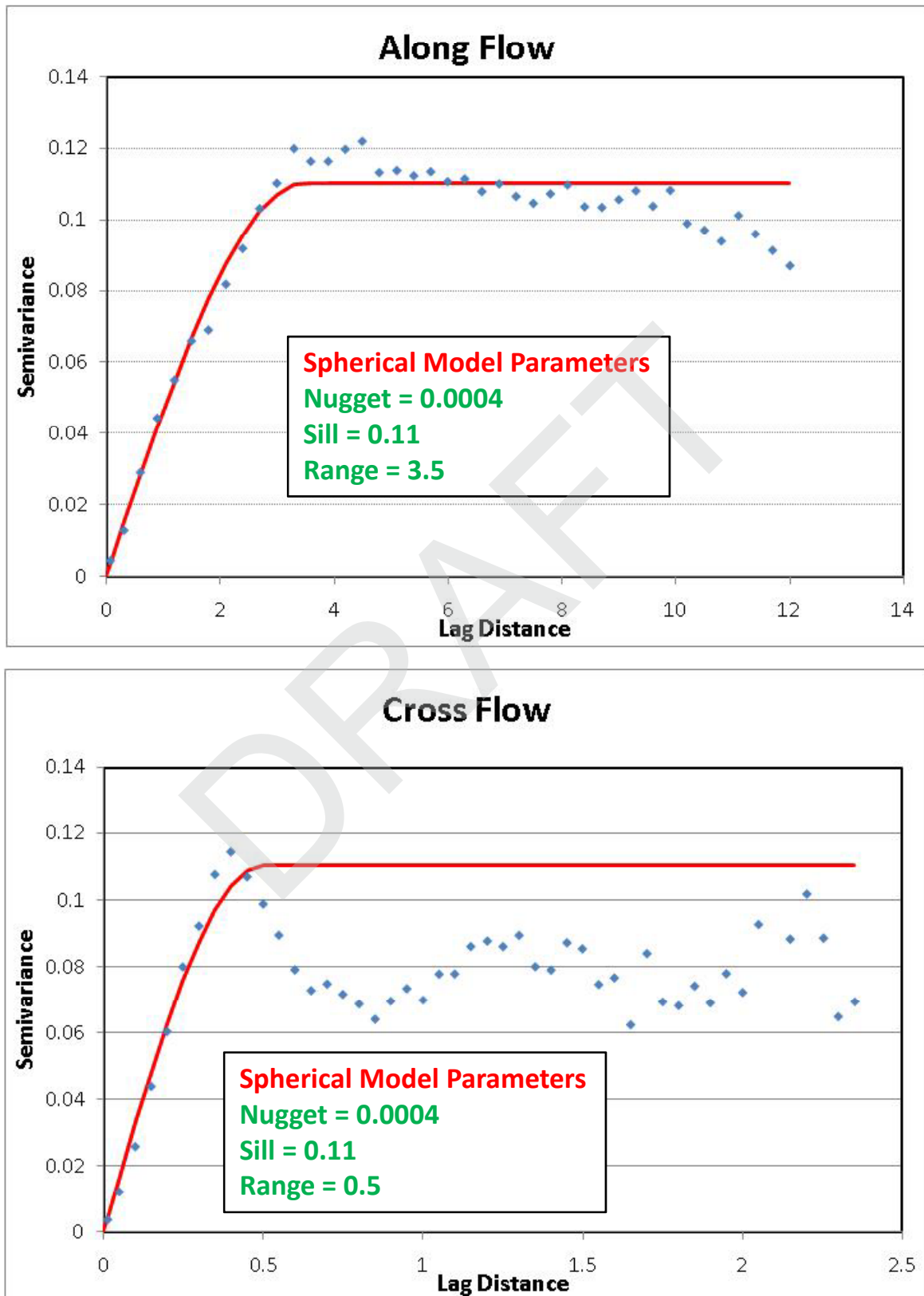


Figure 14c: Directional Semivariograms and Fitted Models for Normal Scores Transformed Residuals of Detrended 1995 Bathymetry

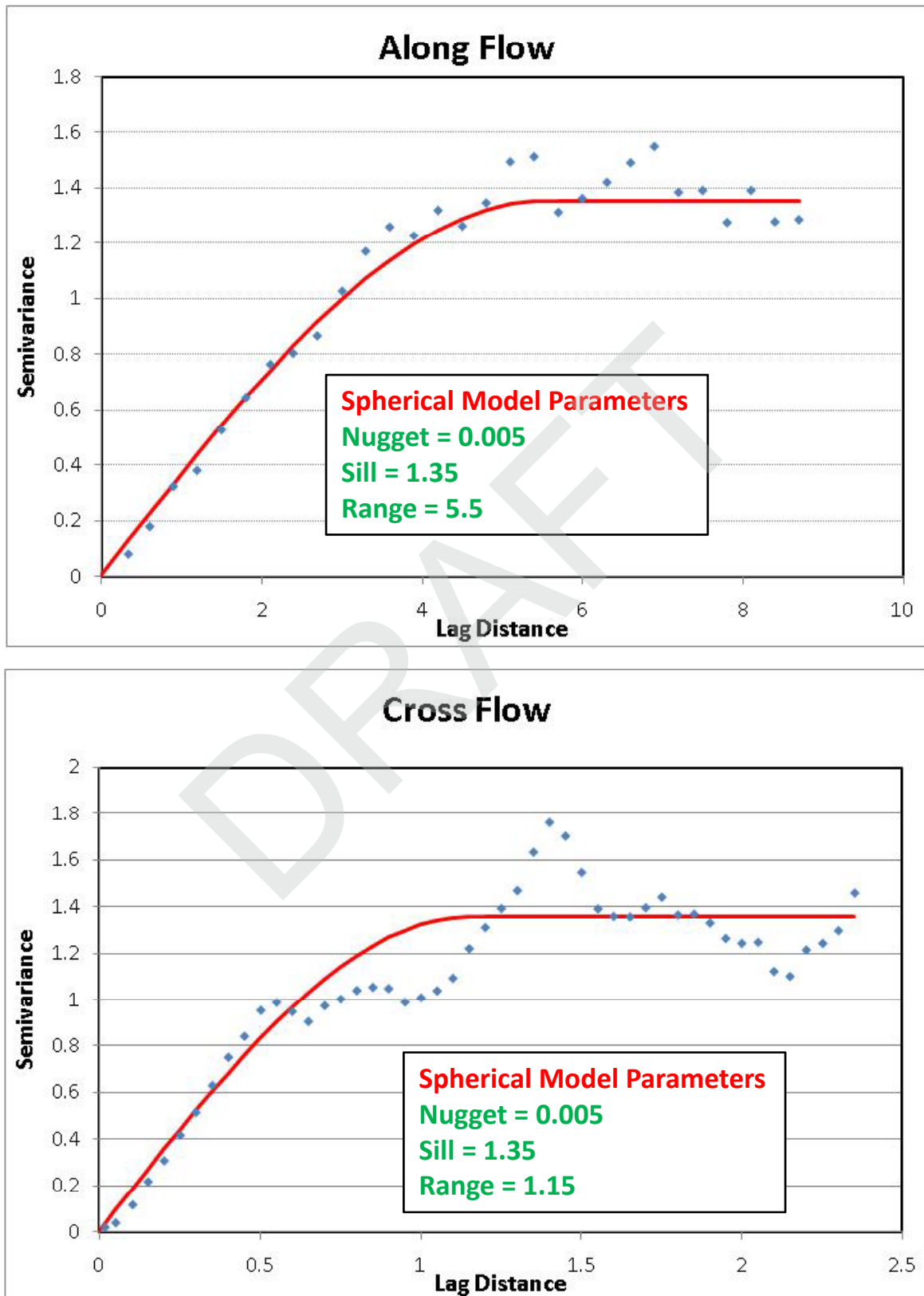


Figure 14d: Directional Semivariograms and Fitted Models for Uniform Scores Transformed Residuals of Detrended 1995 Bathymetry

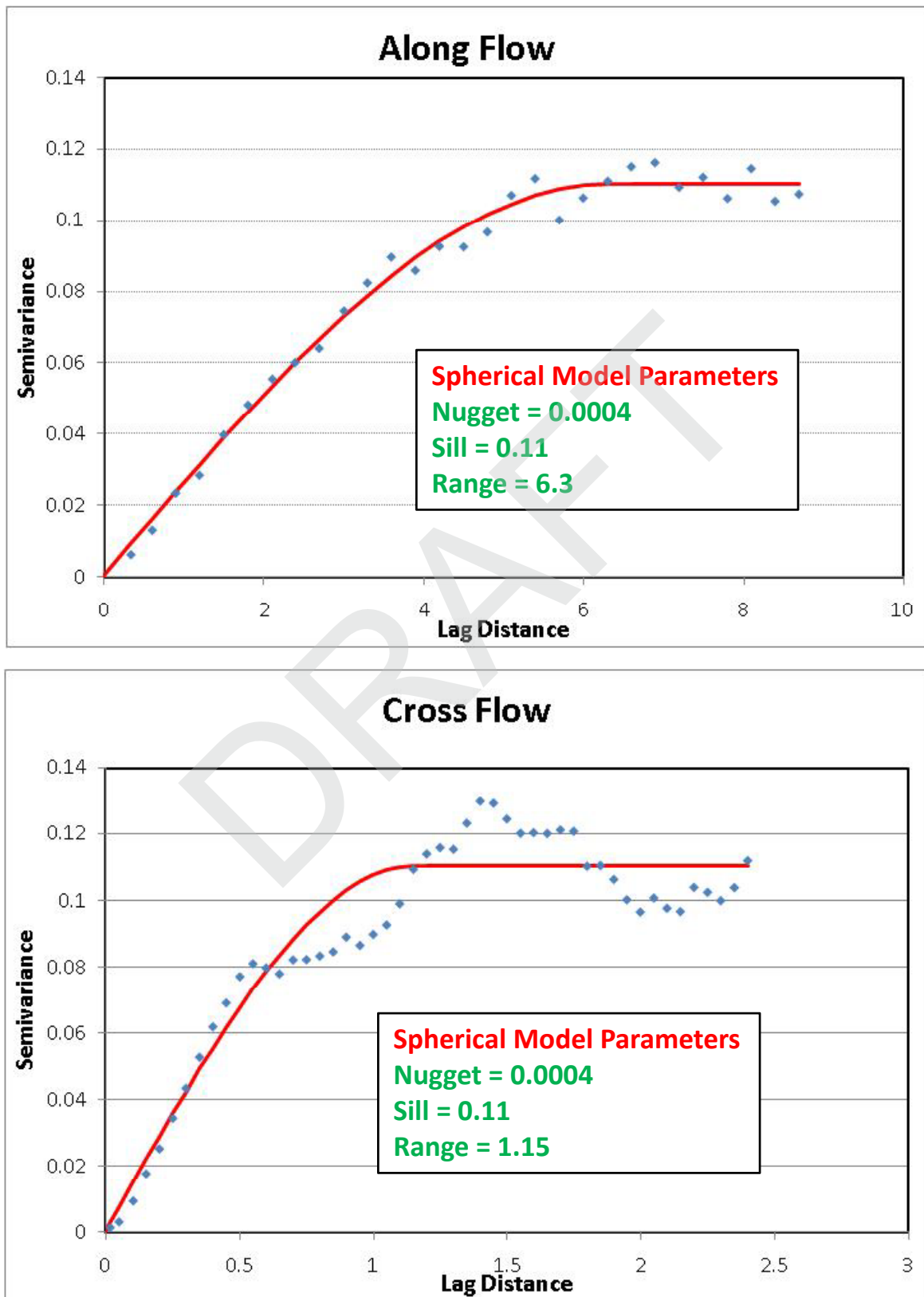


Figure 14e: Directional Semivariograms and Fitted Models for Normal Scores Transformed Residuals of Detrended 1996 Bathymetry

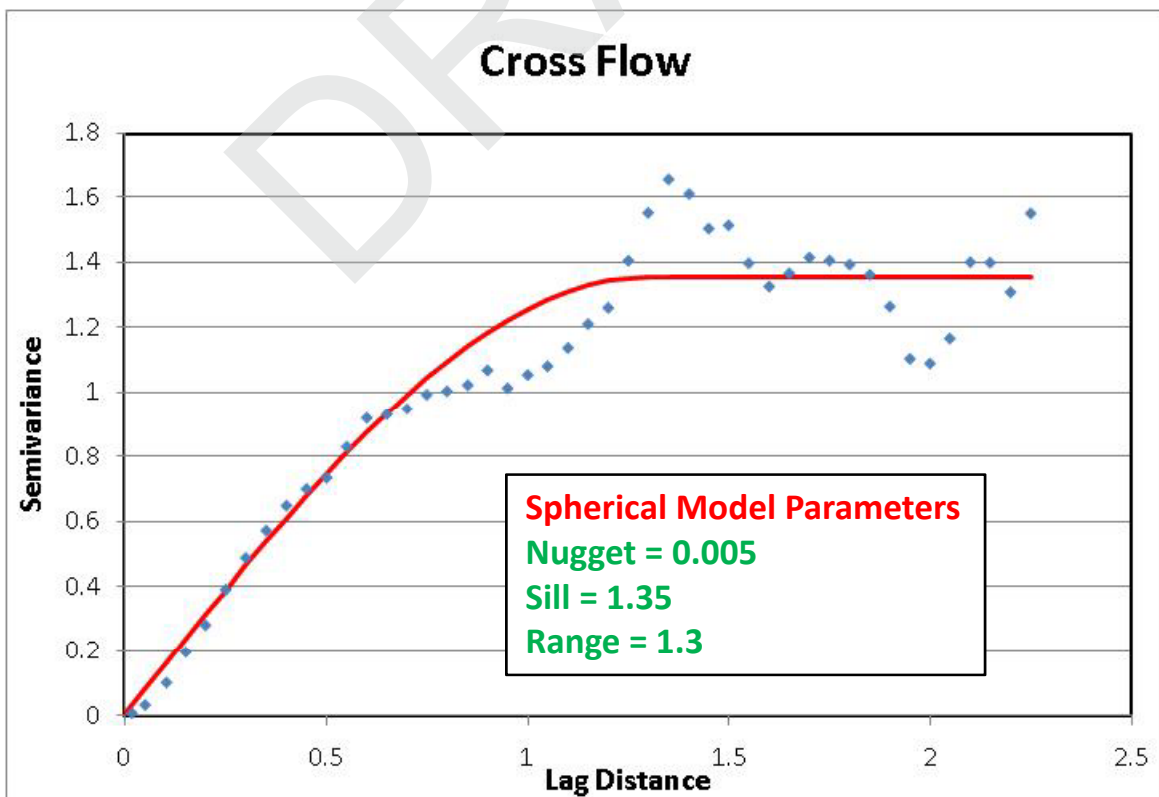
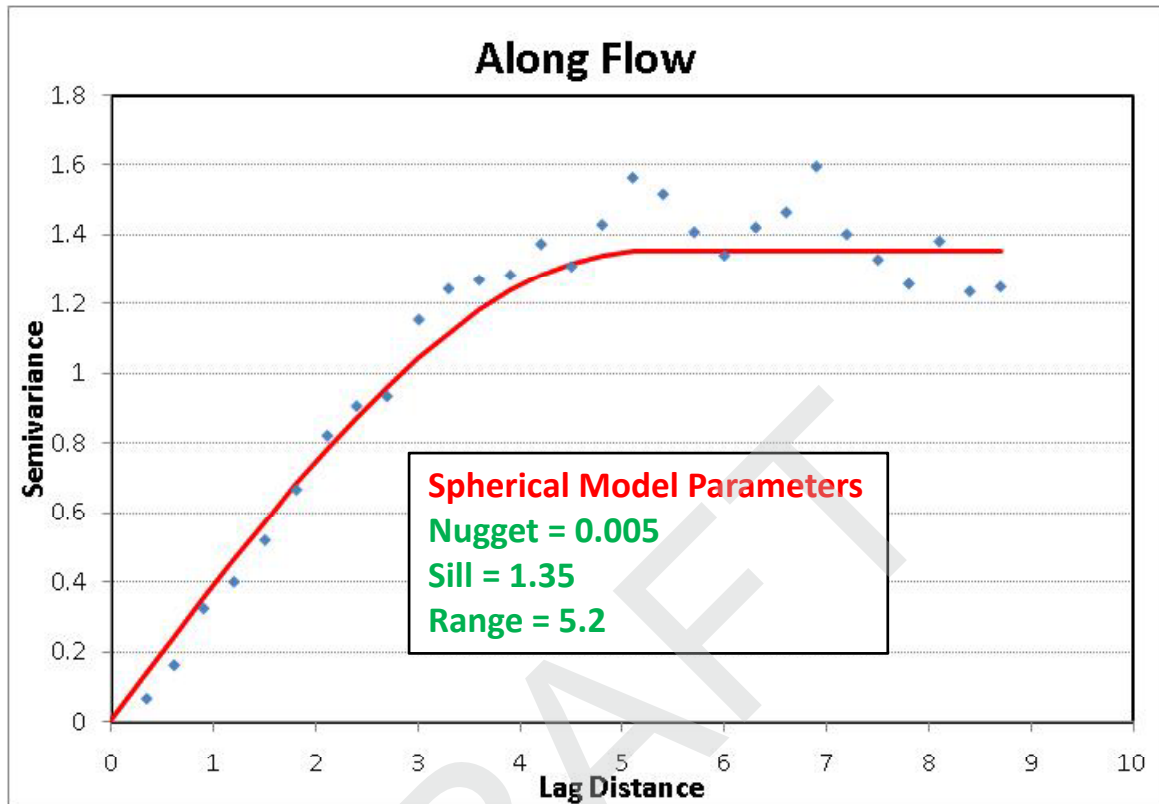


Figure 14f: Directional Semivariograms and Fitted Models for Uniform Scores Transformed Residuals of Detrended 1996 Bathymetry

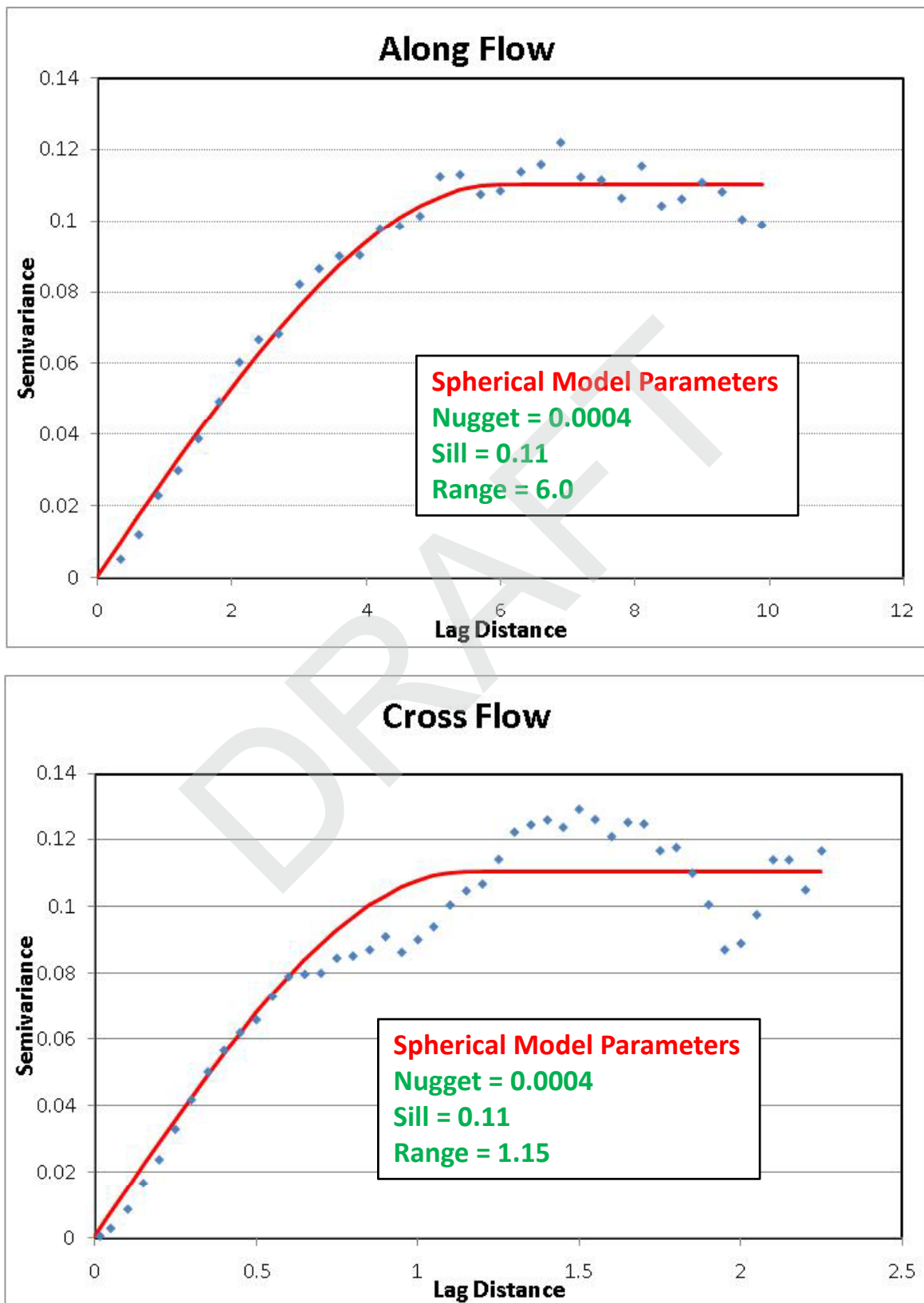


Figure 14g: Directional Semivariograms and Fitted Models for Normal Scores Transformed Residuals of Detrended 1997 Bathymetry

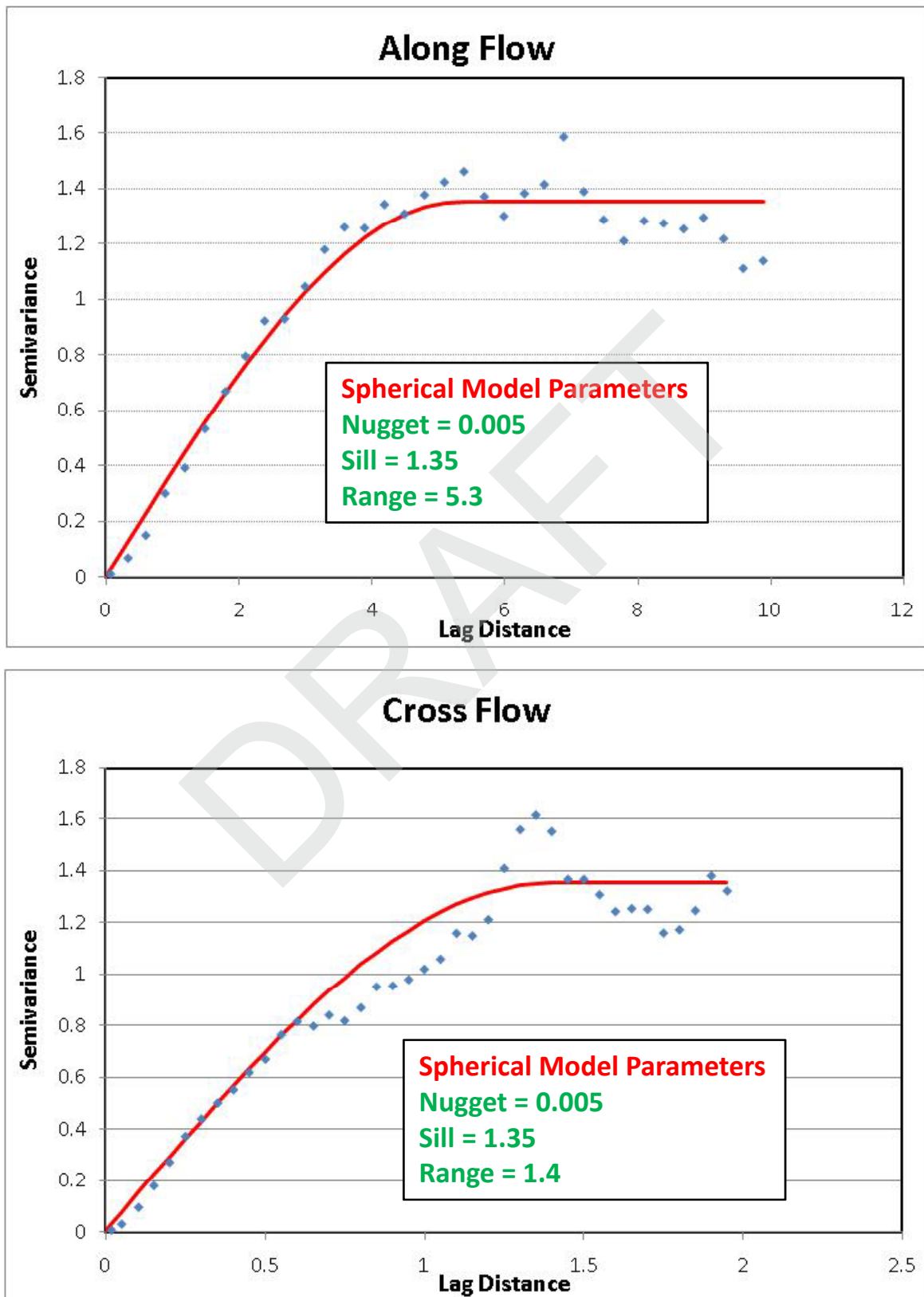


Figure 14h: Directional Semivariograms and Fitted Models for Uniform Scores Transformed Residuals of Detrended 1997 Bathymetry

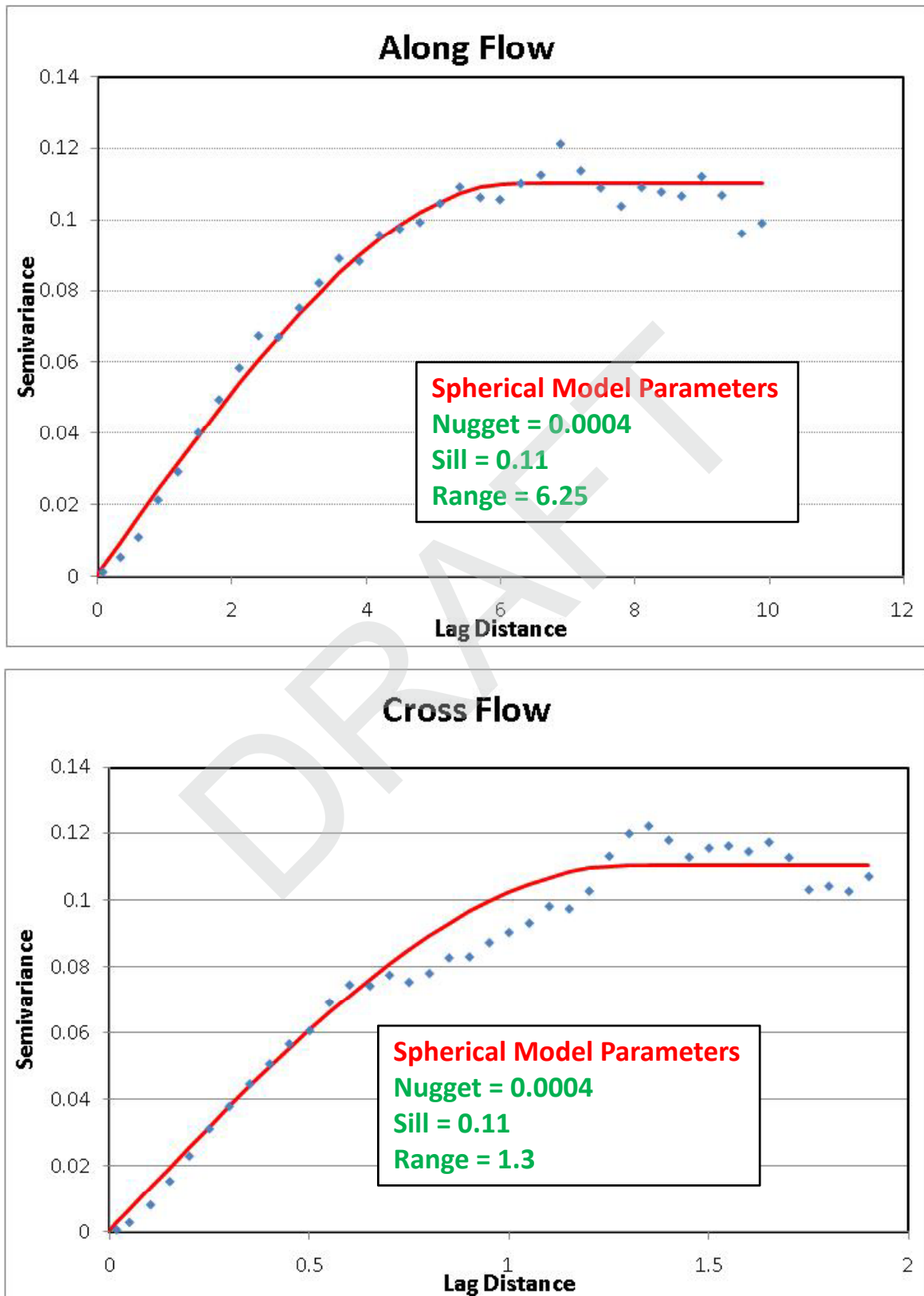


Figure 14i: Directional Semivariograms and Fitted Models for Normal Scores Transformed Residuals of Detrended 1999 Bathymetry

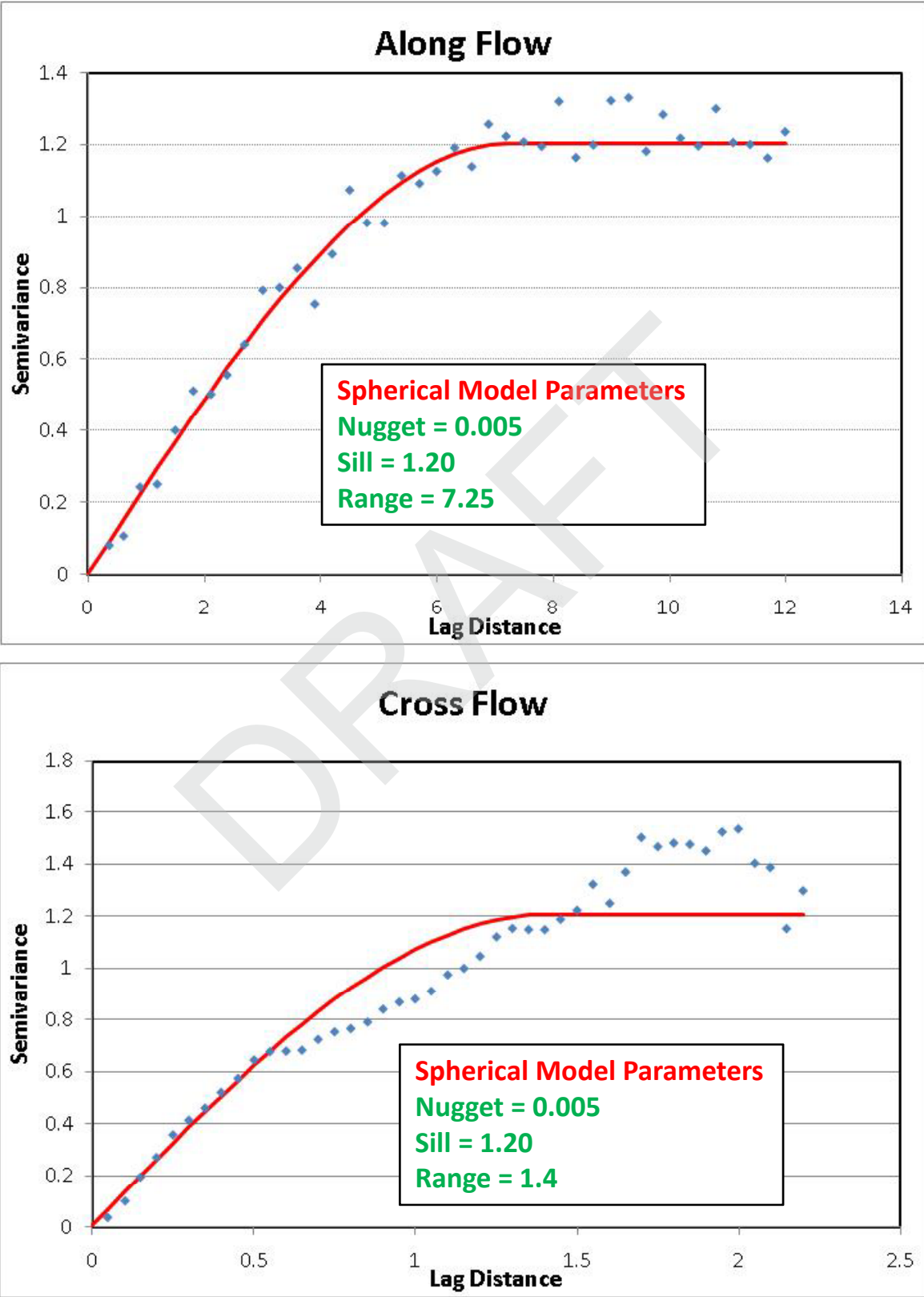


Figure 14j: Directional Semivariograms and Fitted Models for Uniform Scores Transformed Residuals of Detrended 1999 Bathymetry

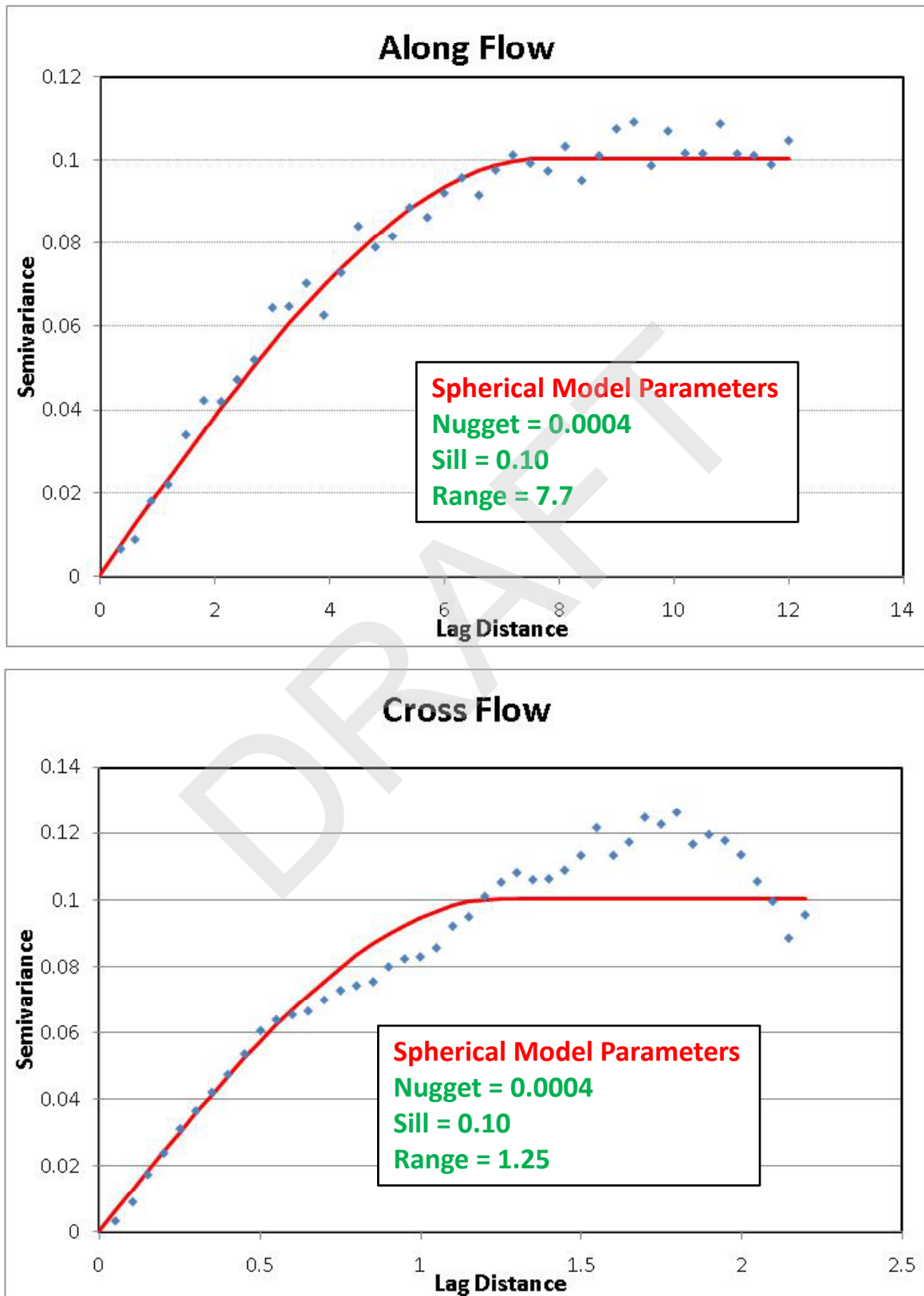


Figure 14k: Directional Semivariograms and Fitted Models for Normal Scores Transformed Residuals of Detrended 2001 Bathymetry

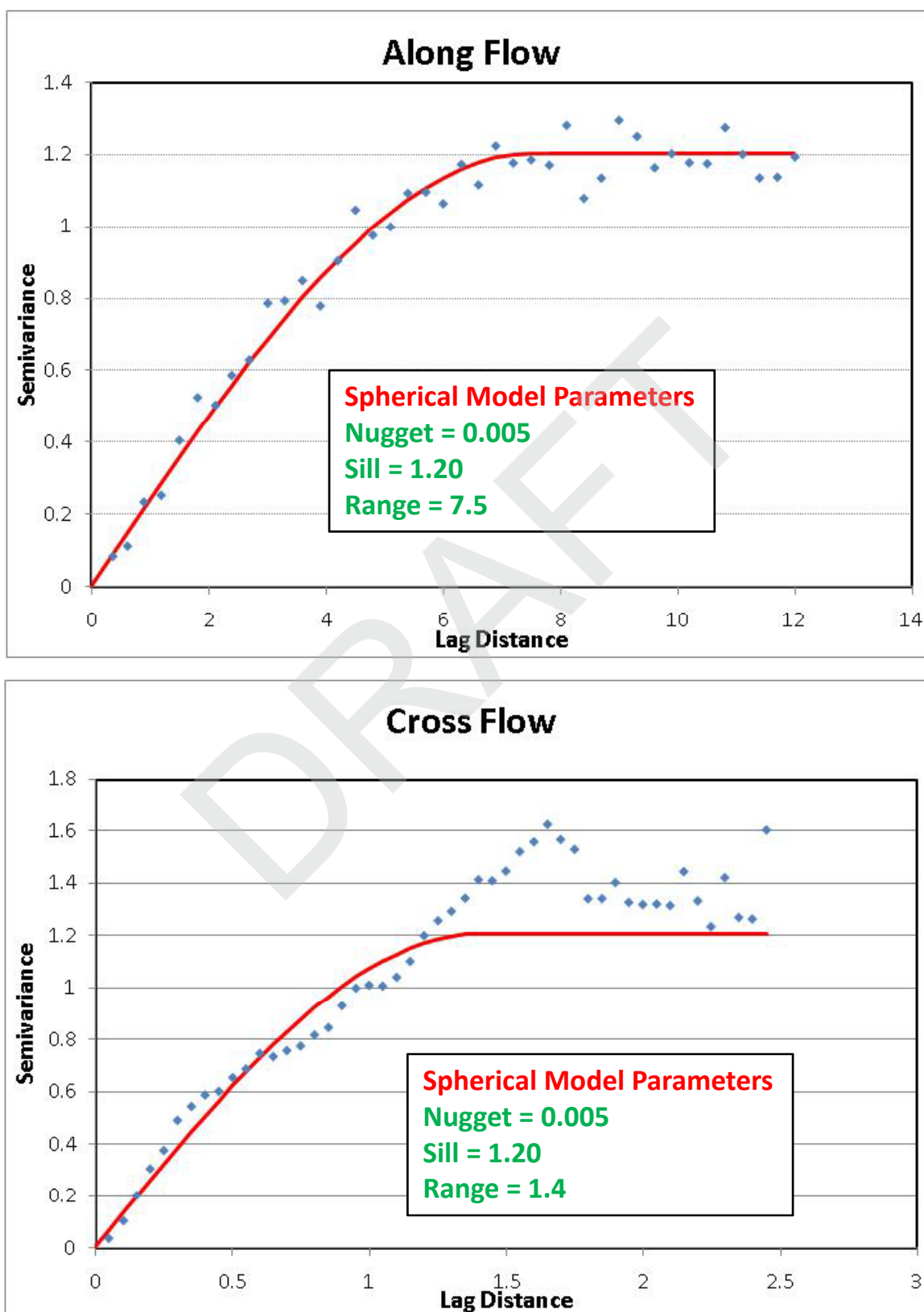


Figure 14I: Directional Semivariograms and Fitted Models for Uniform Scores Transformed Residuals of Detrended 2001 Bathymetry

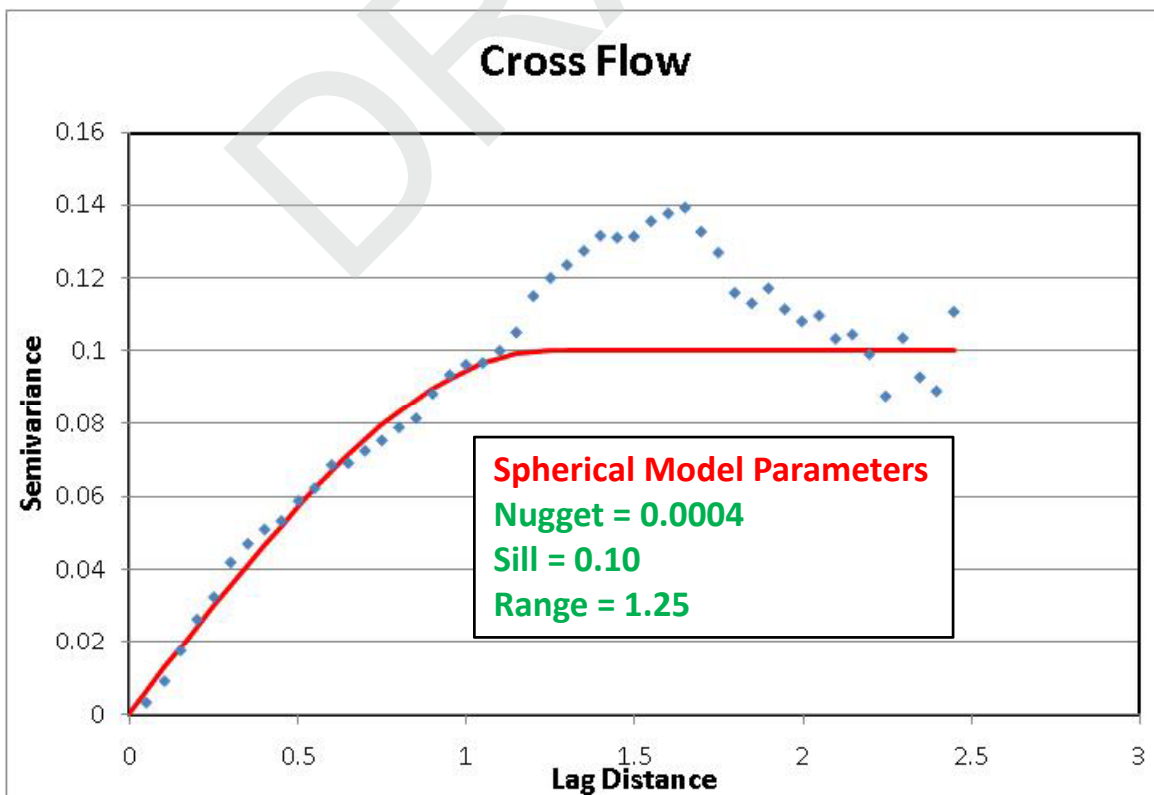
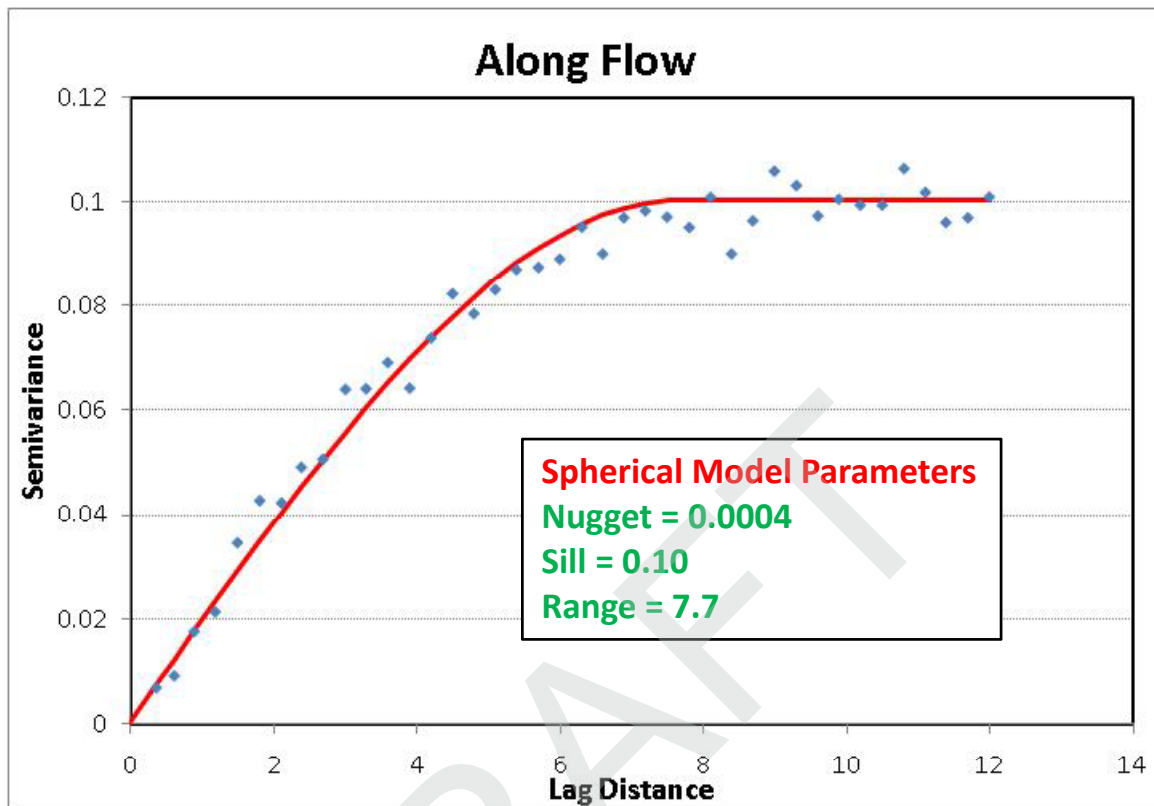


Figure 14m: Directional Semivariograms and Fitted Models for Normal Scores Transformed Residuals of Detrended 2002 Bathymetry

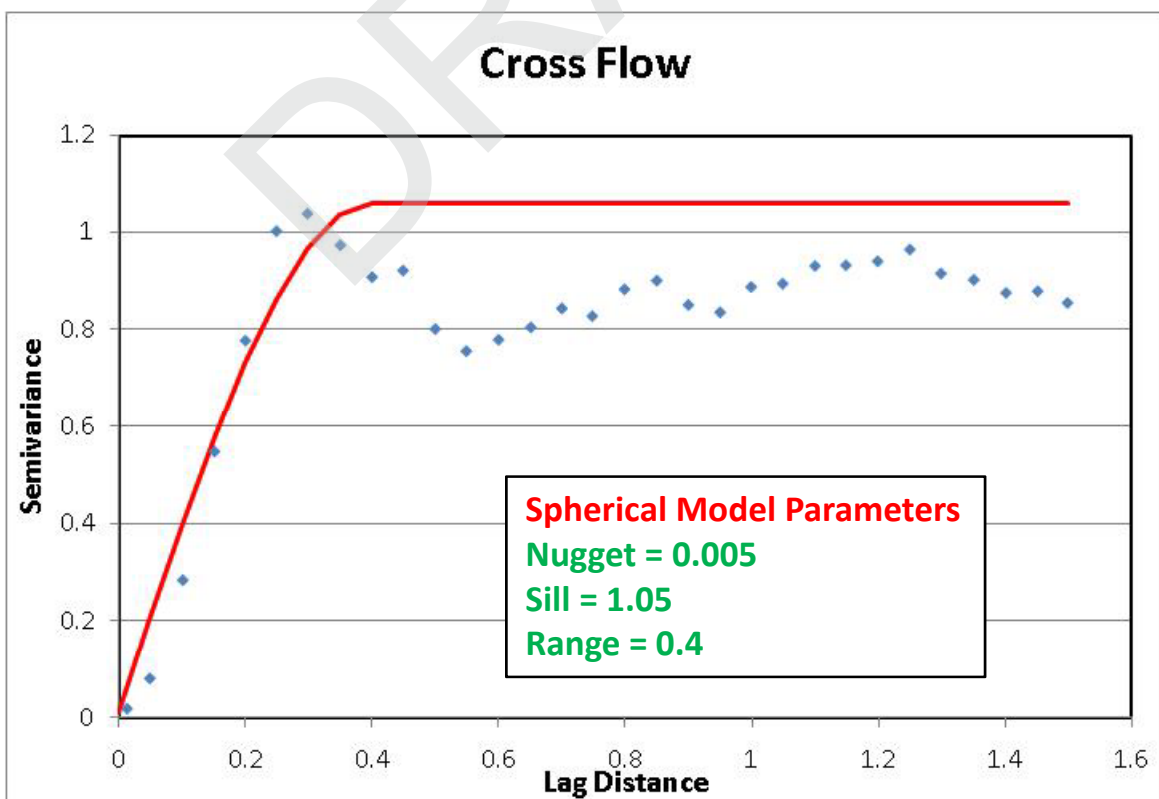
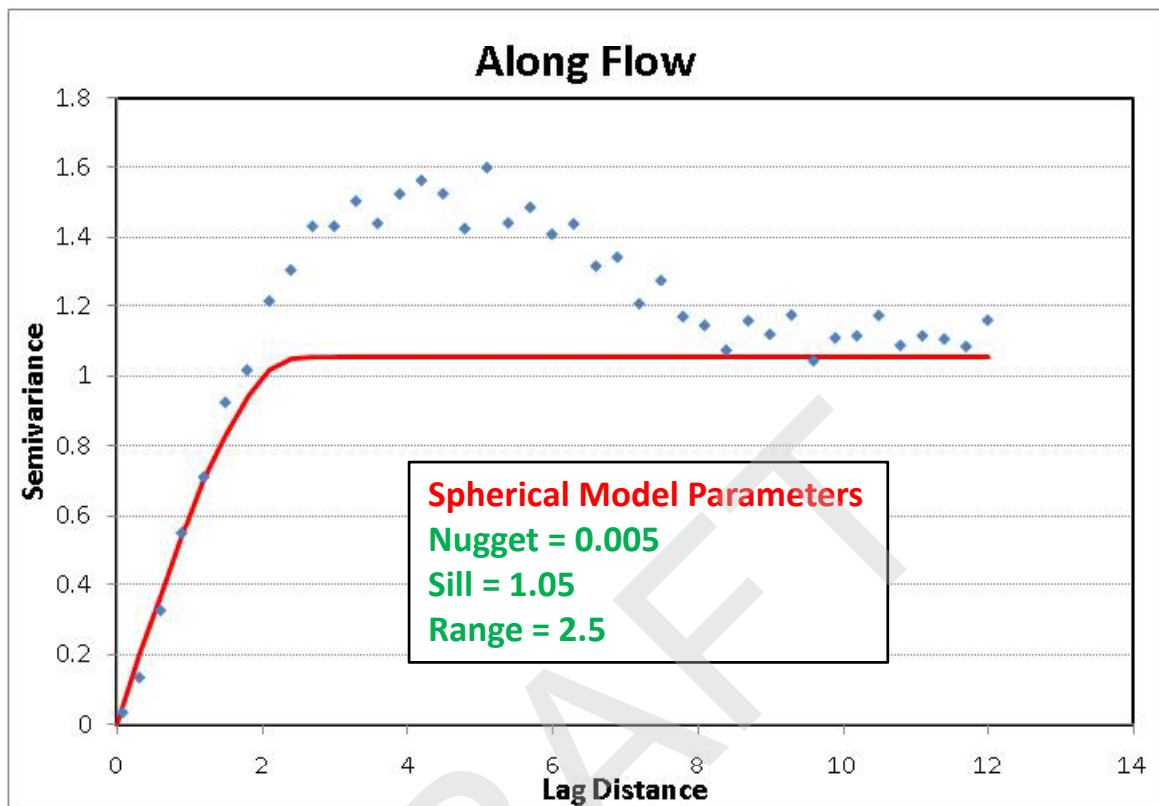


Figure 14n: Directional Semivariograms and Fitted Models for Uniform Scores Transformed Residuals of Detrended 2002 Bathymetry

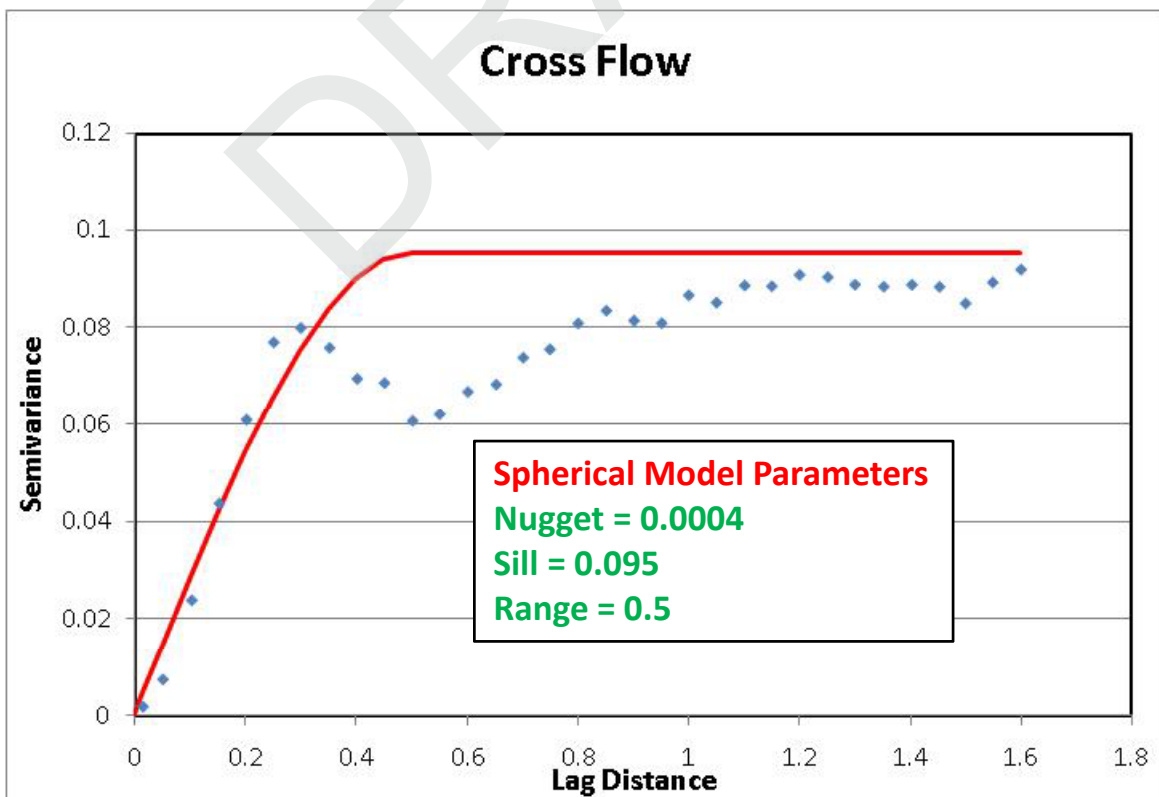
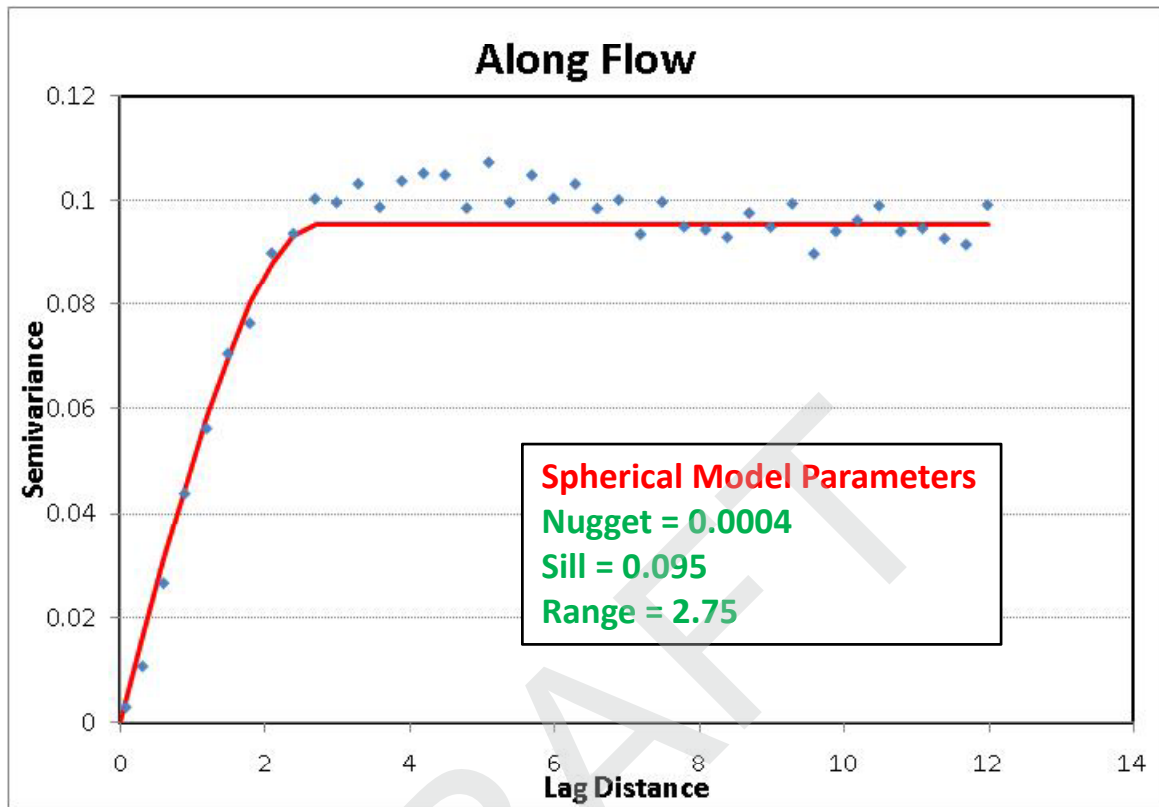


Figure 14o: Directional Semivariograms and Fitted Models for Normal Scores Transformed Residuals of Detrended 2004 Bathymetry

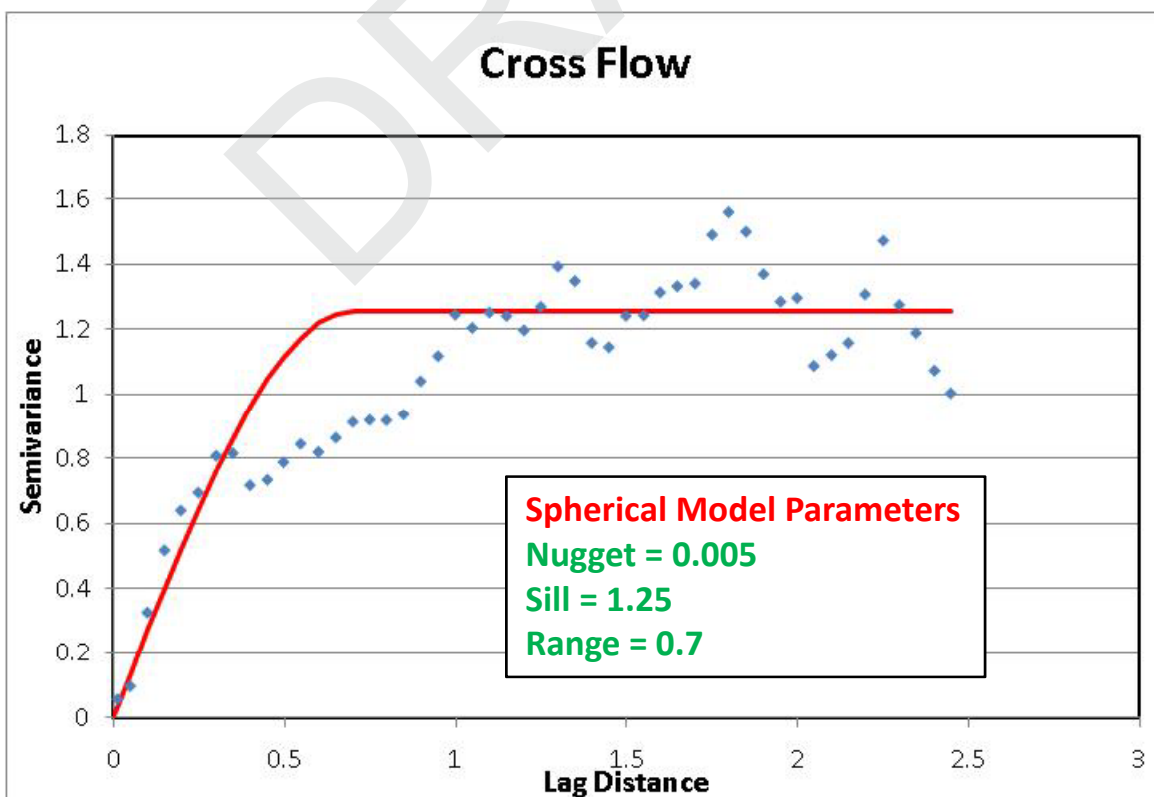
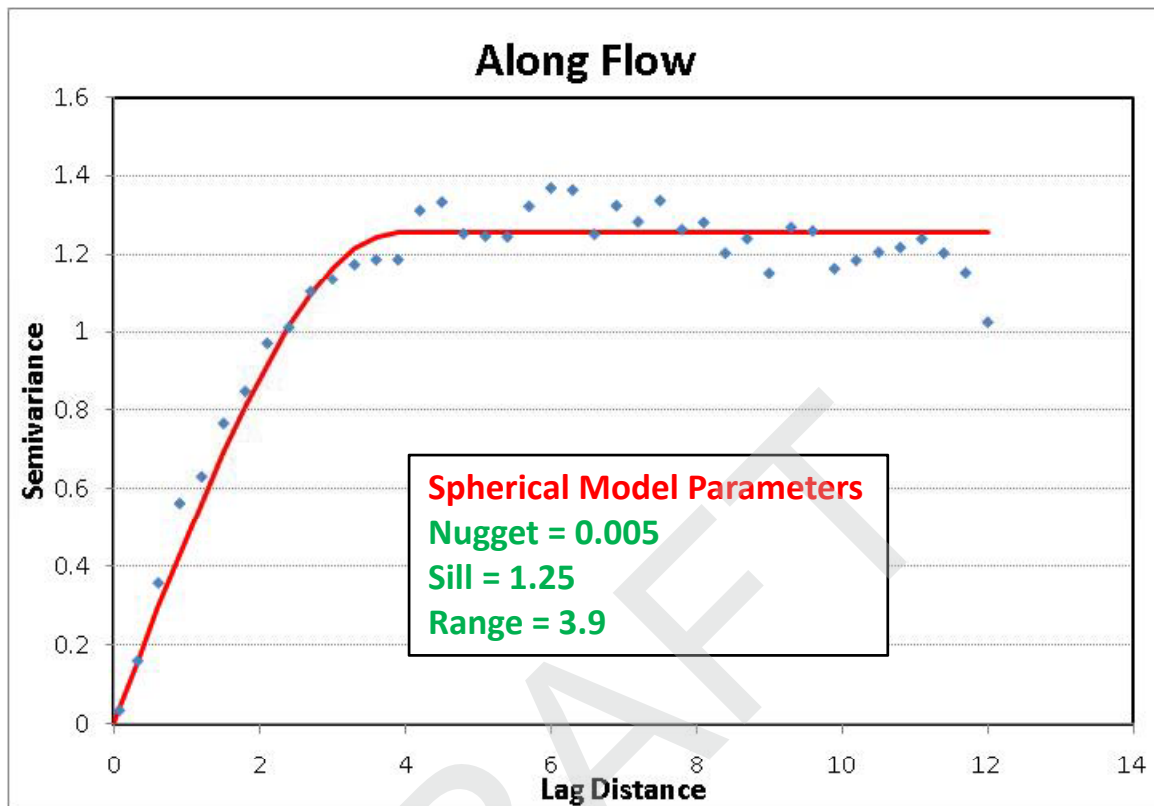


Figure 14p: Directional Semivariograms and Fitted Models for Uniform Scores Transformed Residuals of Detrended 2004 Bathymetry

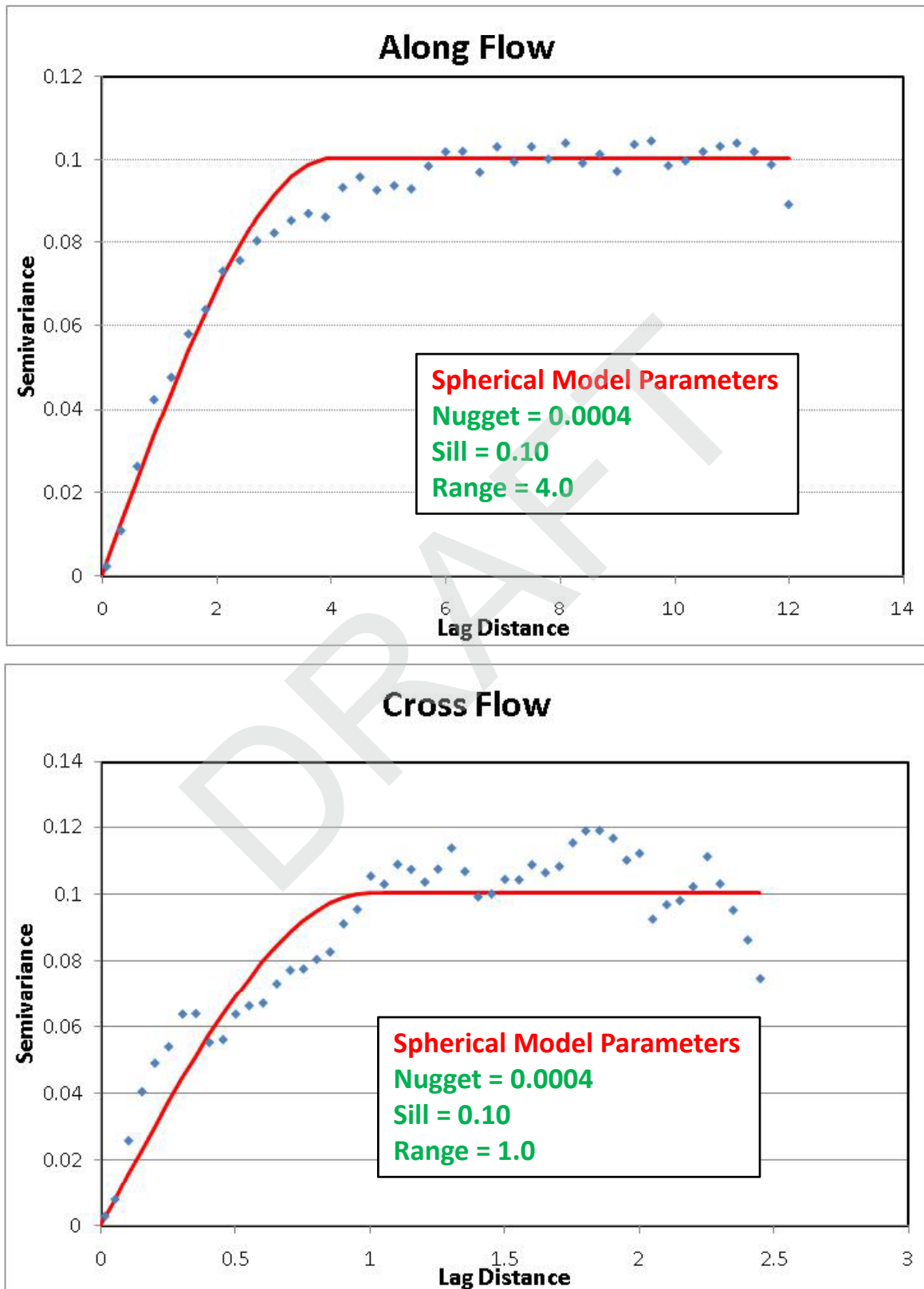


Figure 15: Three realizations of the 1996 bathymetric elevations.

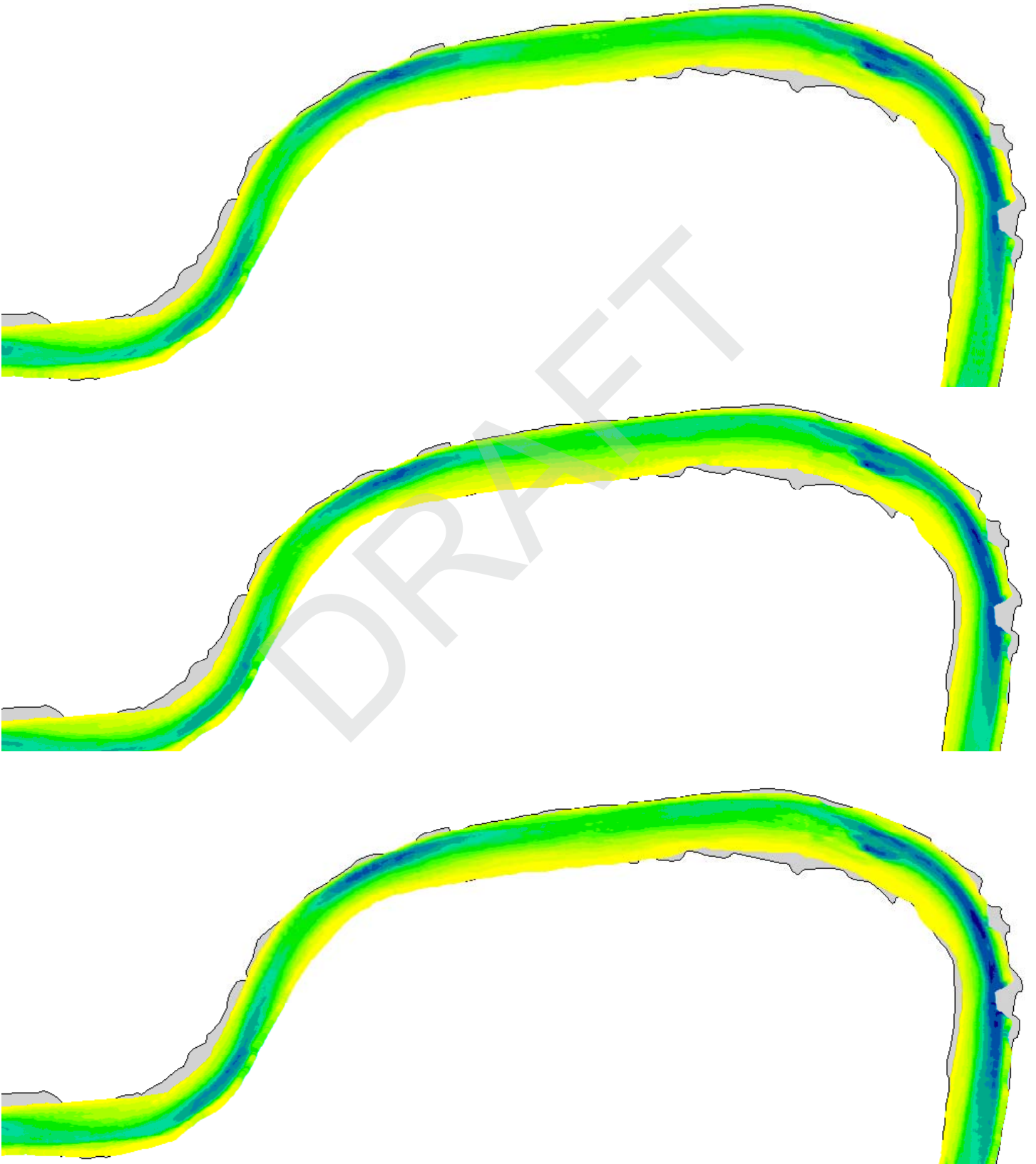
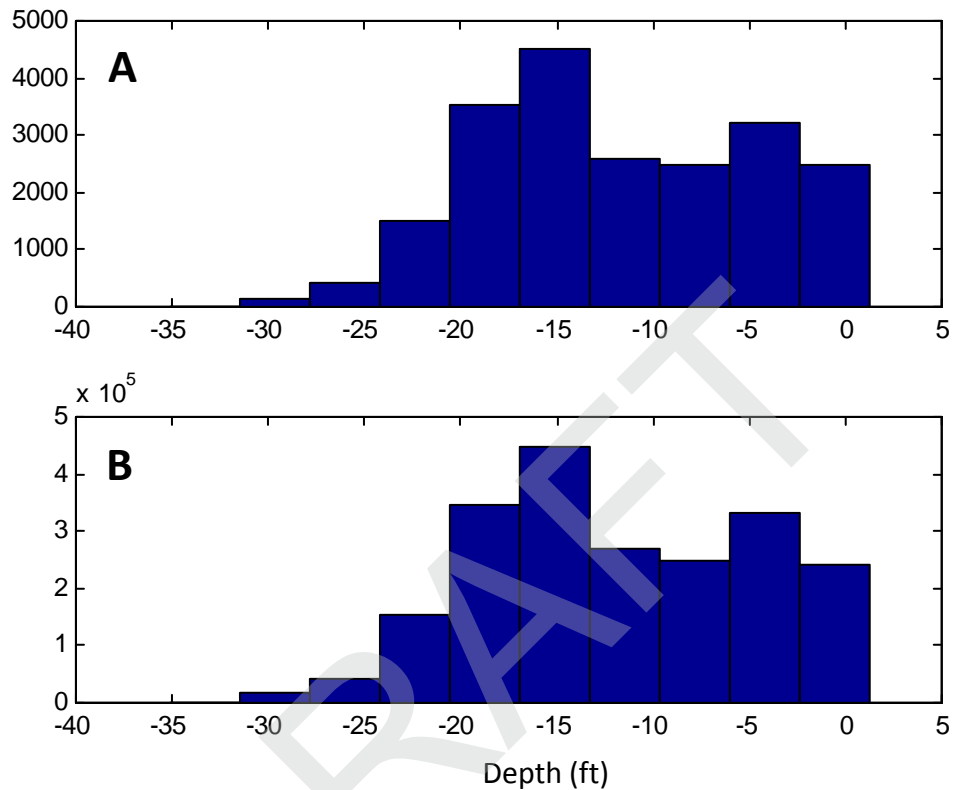


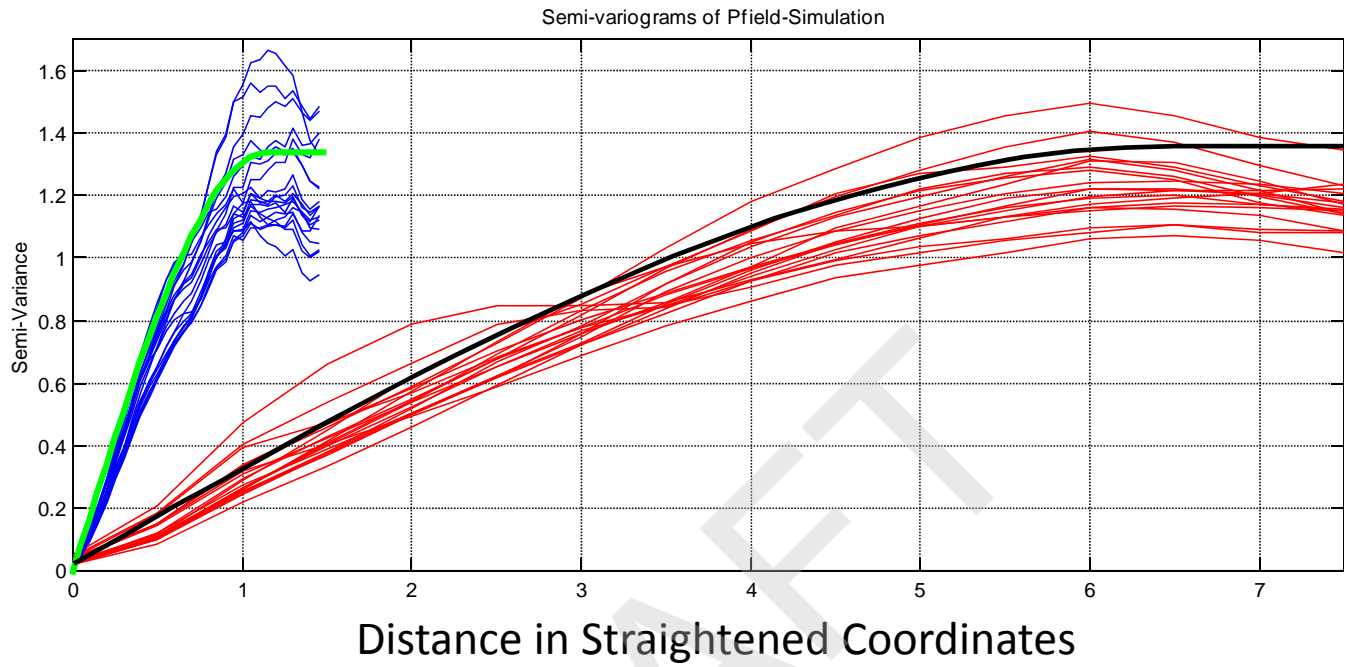
Figure 16: Histogram of sample elevations (Panel A) and simulated elevations (Panel B) for the lower Passaic River in 1995.



Note:

- 1) Simulated elevations represent all locations at which values were simulated, as opposed to the subset of locations at which inter year comparisons were conducted.
- 2) This comparison illustrates that the simulation algorithm reproduces the data histogram.
- 3) Because inter-year comparisons of simulated data were restricted to a smaller lateral extent than the sample data, direct comparison of histograms would be biased toward deeper soundings in the simulated soundings.

Figure 17: Semivariograms for 20 realizations compared with theoretical model semivariograms for cross-flow (green) and long-flow (black) directions.









0 250 500 1,000
Feet

Legend

Area Subject to Erosion
(At least one 6-in. erosion event at a minimum 70% confidence level)

-  All Possible Survey Pair Comparisons
-  Sequential Survey Pair Comparisons

-  Simulation Grid Extent
-  Shoreline as defined by the NJDEP

Conditional Simulation Results
Showing Areas Subject to 6 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration

Figure 18a

2010



P:\0285924\Mapping\CSM_MassBalance\bathymetry_frequency_depth_map_wbookmark_v4.mxd



Legend

Area Subject to Erosion
(At least one 6-in. erosion event at a minimum 70% confidence level)

- All Possible Survey Pair Comparisons
- Sequential Survey Pair Comparisons

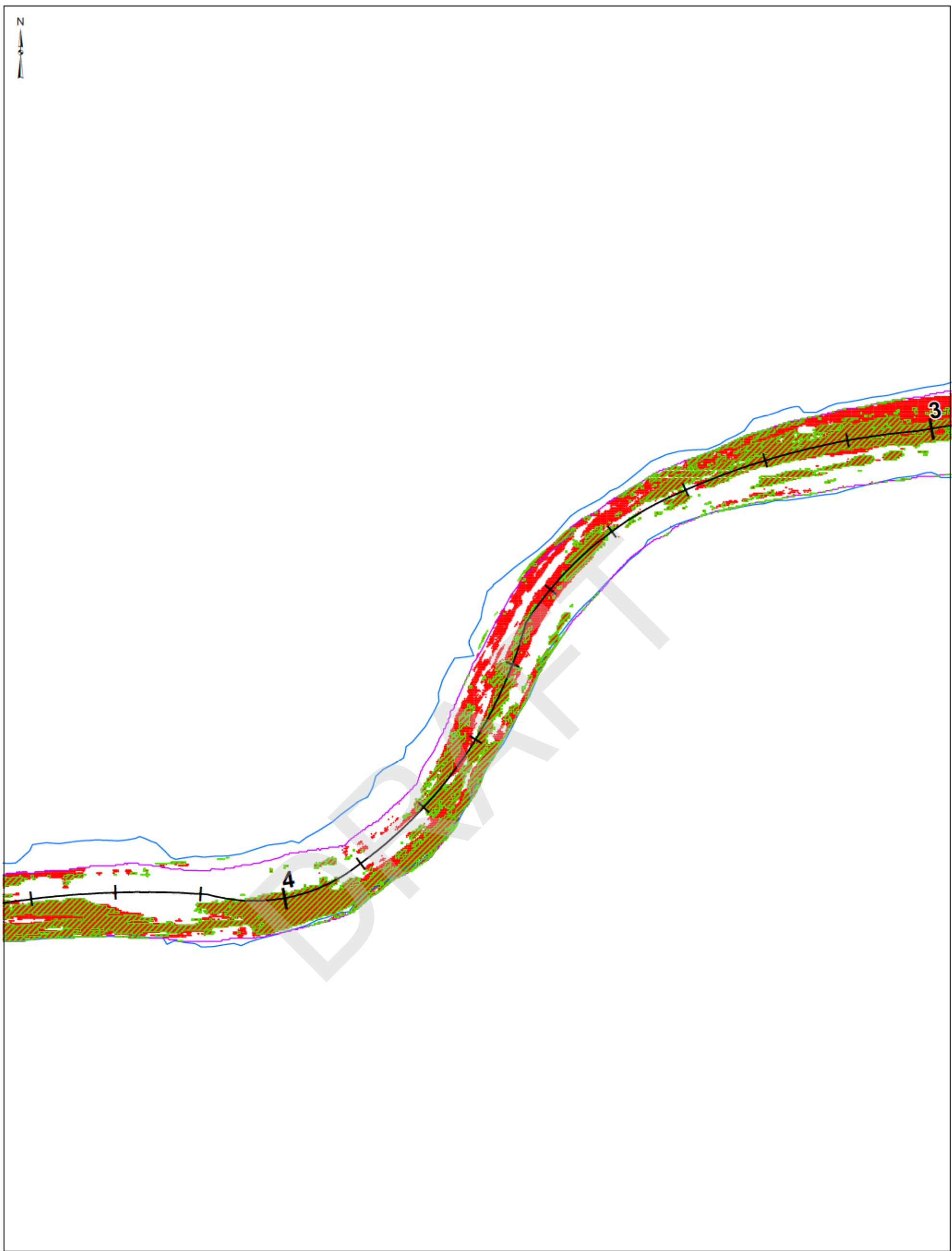
- Simulation Grid Extent
- Shoreline as defined by the NJDEP

Conditional Simulation Results
Showing Areas Subject to 6 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration

Figure 18b

2010

P:\0285924\Mapping\CSM_MassBalance\bathymetry_frequency_depth_map_wbookmark_v4.mxd



0 250 500 1,000 Feet

Legend

Area Subject to Erosion
(At least one 6-in. erosion event at a minimum 70% confidence level)

All Possible Survey Pair Comparisons

Sequential Survey Pair Comparisons

Simulation Grid Extent

Shoreline as defined by the NJDEP

Conditional Simulation Results
Showing Areas Subject to 6 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration

Figure 18c

2010

P:\0285924\Mapping\CSM_MassBalance\bathymetry_frequency_depth_map_wbookmark_v4.mxd



Legend

Area Subject to Erosion
(At least one 6-in. erosion event at a minimum 70% confidence level)

All Possible Survey Pair Comparisons

Sequential Survey Pair Comparisons

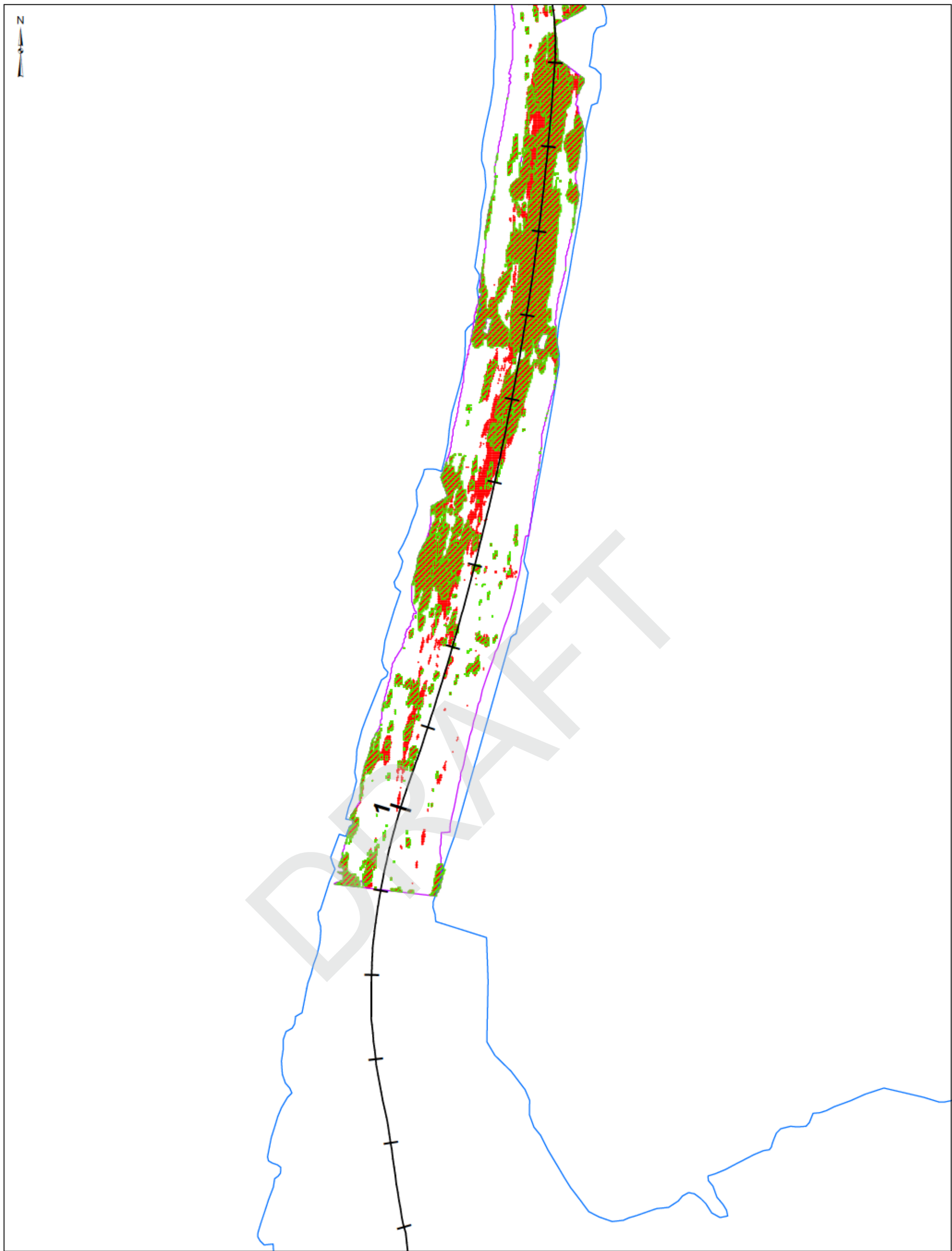
Simulation Grid Extent

Shoreline as defined by the NJDEP

Conditional Simulation Results
Showing Areas Subject to 6 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration

Figure 18d
2010

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Legend

Area Subject to Erosion
(At least one 6-in. erosion event at a minimum 70% confidence level)

All Possible Survey Pair Comparisons

Sequential Survey Pair Comparisons

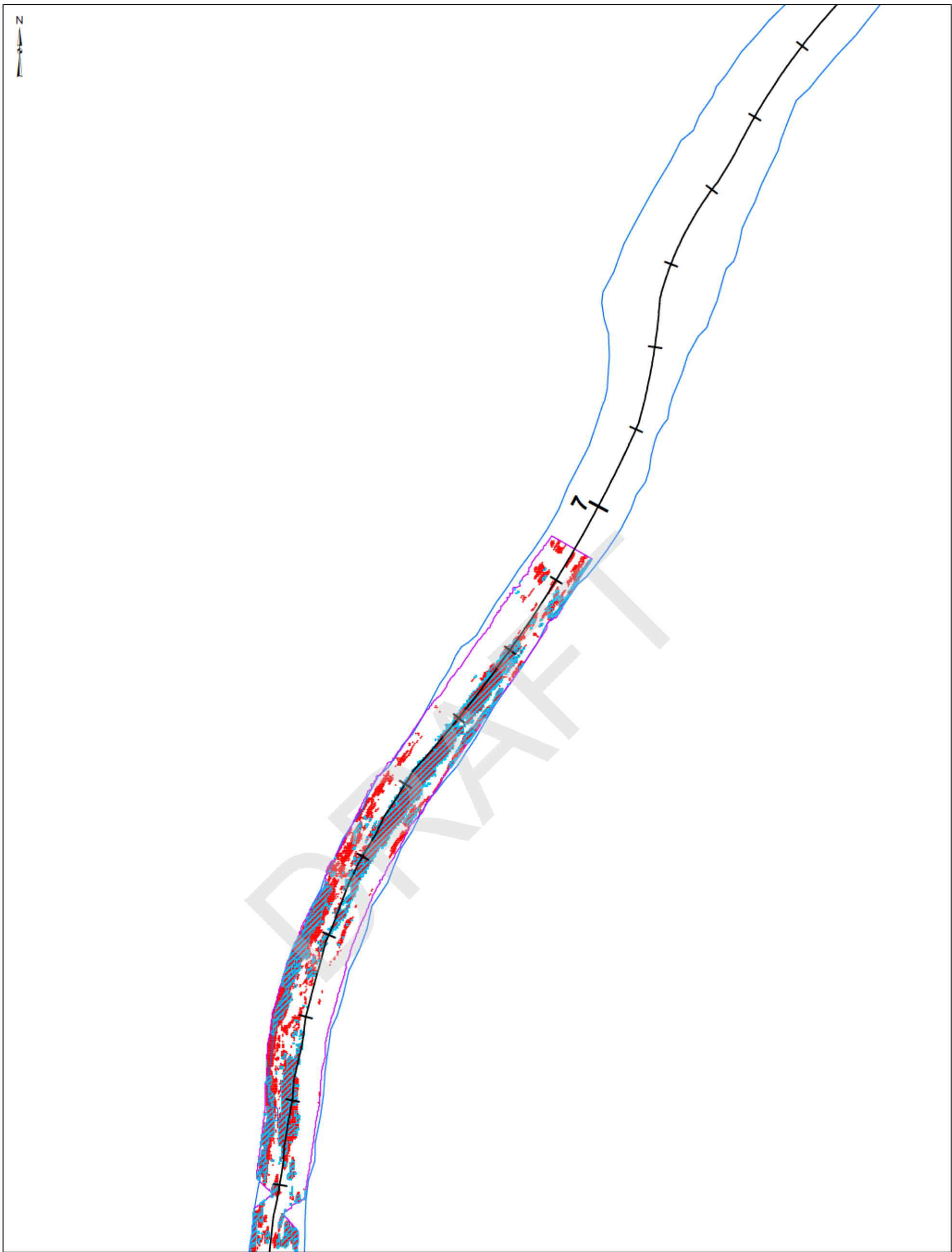
Simulation Grid Extent

Shoreline as defined by the NJDEP

**Conditional Simulation Results
Showing Areas Subject to 6 inches of Erosion at
a Minimum 70% Level of Confidence**
Lower Passaic River Restoration

Figure 18e
2010

P:\0285924\Mapping\CSM_MassBalance\bathymetry_frequency_depth_map_wbookmark_v4.mxd



Legend

Area Subject to Erosion
(At least one 12-in. erosion event at a minimum 70% confidence level)

● All Possible Survey Pair Comparisons

▨ Sequential Survey Pair Comparison

▭ Simulation Grid Extent

— Shoreline as defined by the NJDEP



Conditional Simulation Results
Showing Areas Subject to 12 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration

Figure 19a

2010

P:\0285924\Mapping\CSM_MassBalance\bathymetry_frequency_depth_map_wbookmark_v4.mxd



0 250 500 1,000 Feet

Legend

Area Subject to Erosion
(At least one 12-in. erosion event at a minimum 70% confidence level)

● All Possible Survey Pair Comparisons

Sequential Survey Pair Comparison

Simulation Grid Extent

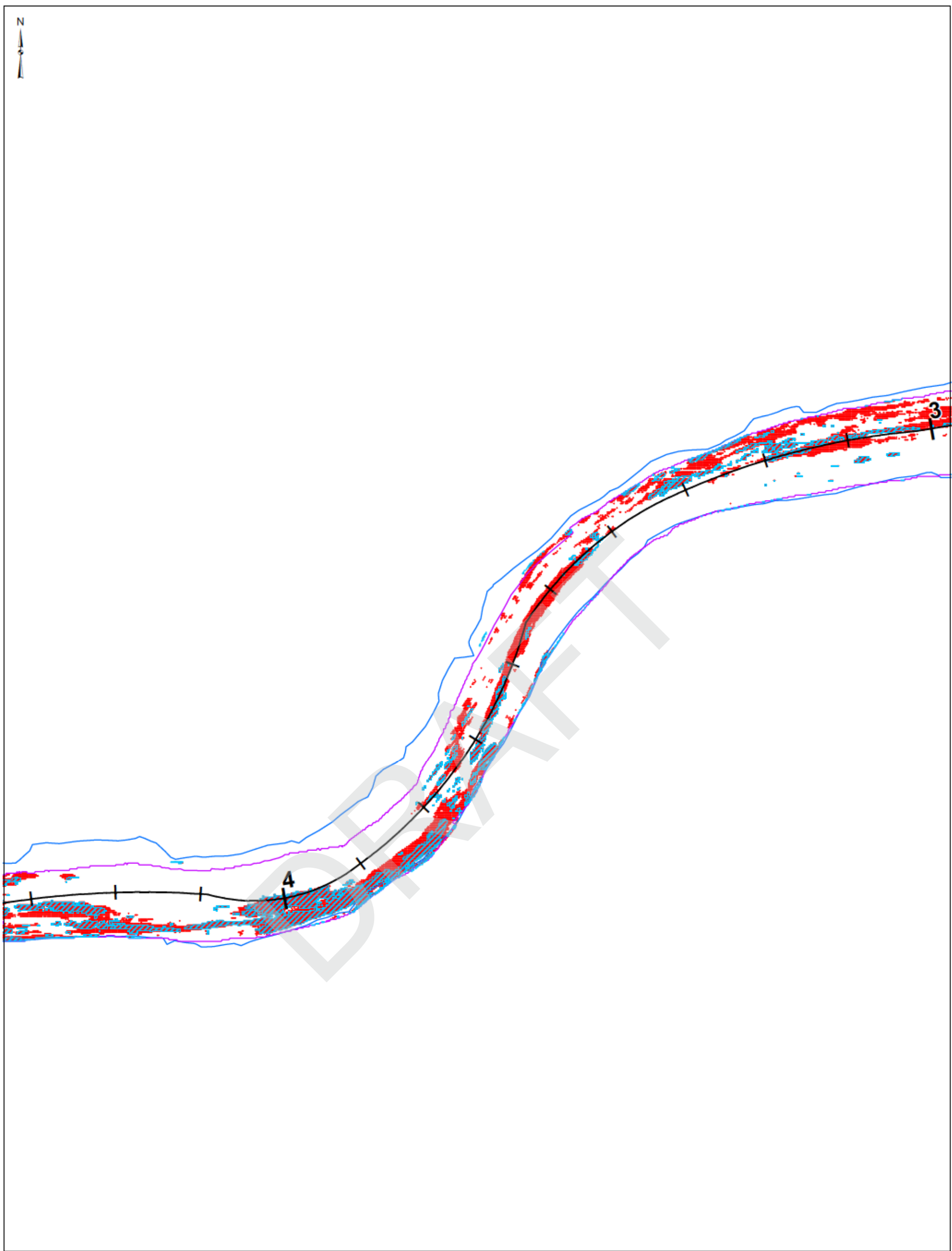
— Shoreline as defined by the NJDEP



Conditional Simulation Results
Showing Areas Subject to 12 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration



Figure 19b
2010



P:\0285924\Mapping\CSM_MassBalance\bathymetry_frequency_depth_map_wbookmark_v4.mxd



Legend

Area Subject to Erosion
(At least one 12-in. erosion event at a minimum 70% confidence level)

-  All Possible Survey Pair Comparisons
-  Sequential Survey Pair Comparison

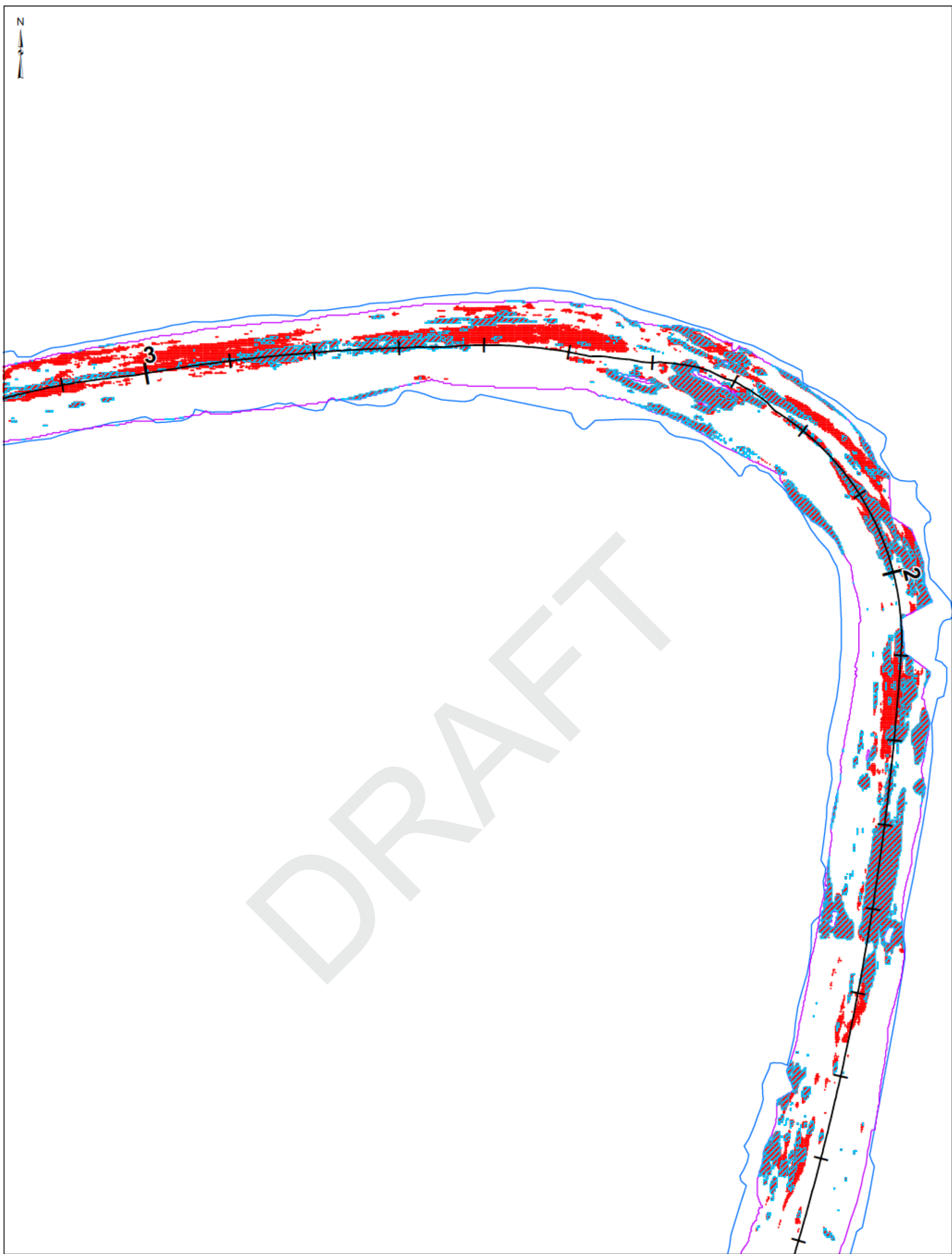
-  Simulation Grid Extent
-  Shoreline as defined by the NJDEP



Conditional Simulation Results
Showing Areas Subject to 12 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration

Figure 19c
2010

P:\0285924\Mapping\CSM_MassBalance\bathymetry_frequency_depth_map_wbookmark_v4.mxd



0 250 500 1,000 Feet

Legend

Area Subject to Erosion
(At least one 12-in. erosion event at a minimum 70% confidence level)

● All Possible Survey Pair Comparisons

Sequential Survey Pair Comparison

Simulation Grid Extent

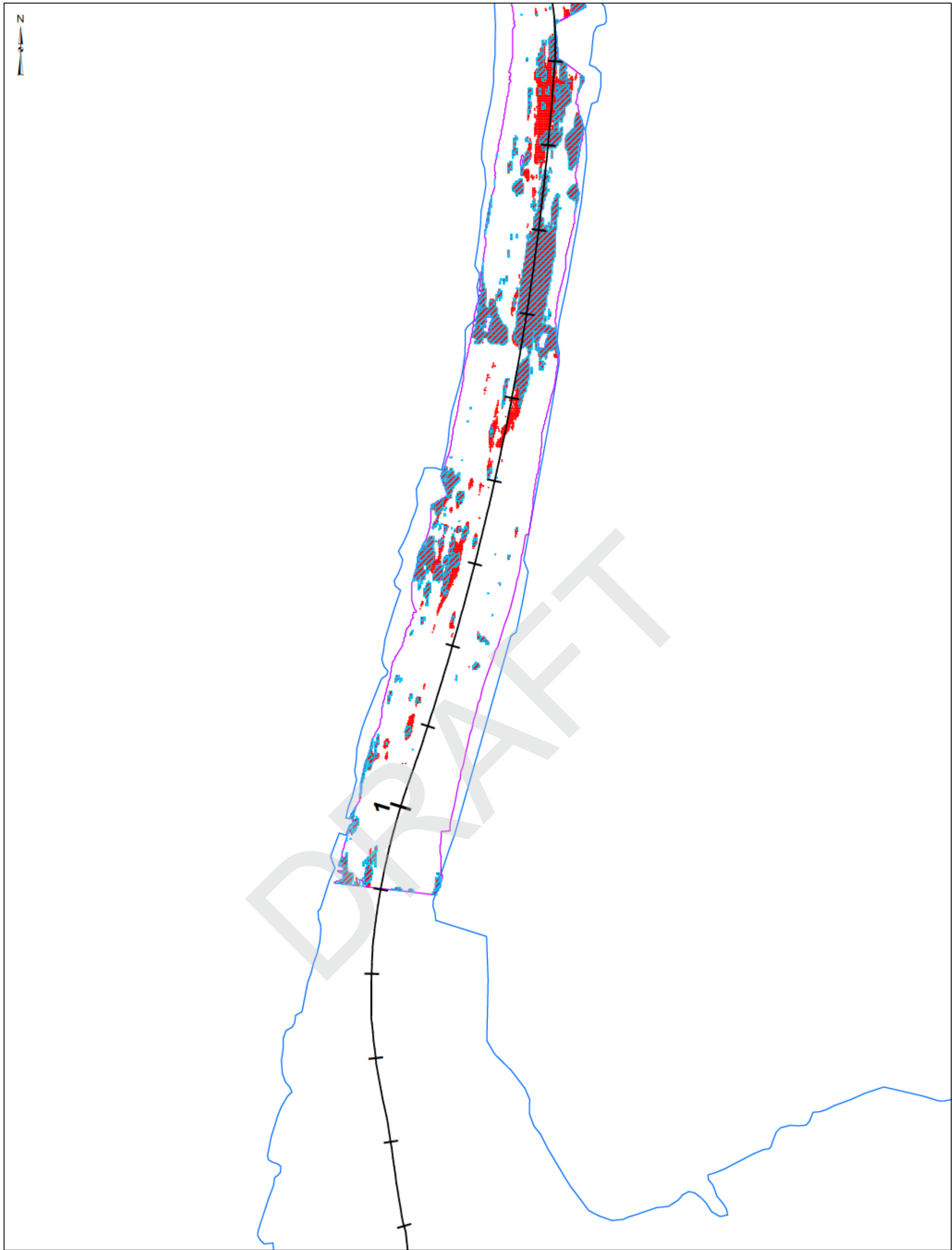
Shoreline as defined by the NJDEP



Conditional Simulation Results
Showing Areas Subject to 12 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration

Figure 19d
2010

P:\0285924\Mapping\CSM_MassBalance\bathymetry_frequency_depth_map_wbookmark_v4.mxd



0 250 500 1,000 Feet

Legend

Area Subject to Erosion
(At least one 12-in. erosion event at a minimum 70% confidence level)

All Possible Survey Pair Comparisons

Sequential Survey Pair Comparison

Simulation Grid Extent

Shoreline as defined by the NJDEP

Conditional Simulation Results
Showing Areas Subject to 12 inches of Erosion at
a Minimum 70% Level of Confidence
Lower Passaic River Restoration

Figure 19e
2010



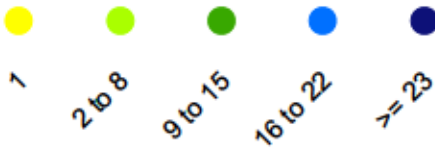
P:\0285924\Mapping\CSM_MassBalance\bathy_simulation_deposition_v2.mxd



Legend

Area Subject to Erosion at 70% Confidence Level

Number of Deposition Observations at 70% Confidence Level



Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent
Shoreline as defined by the NJDEP

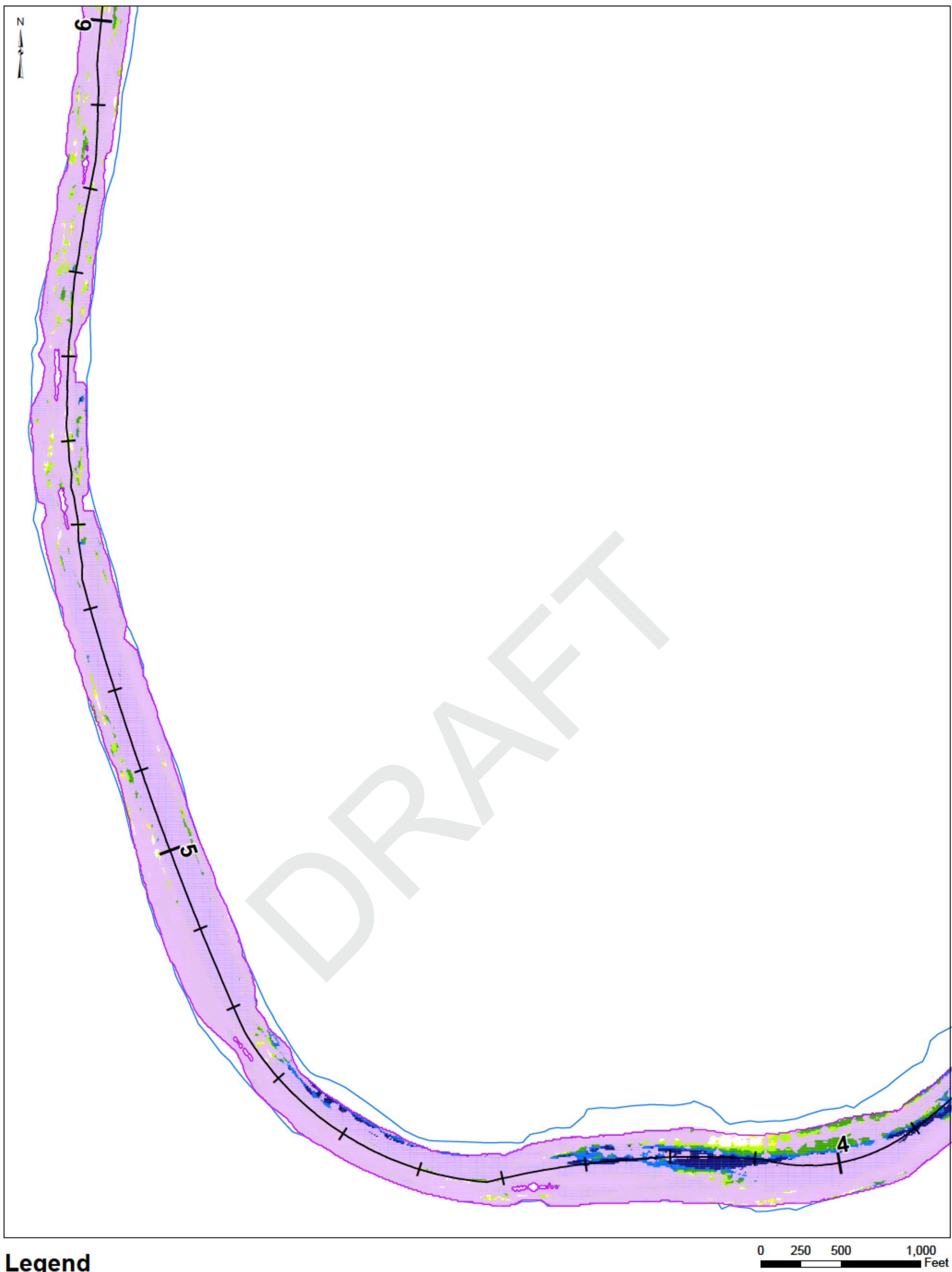


Conditional Simulation Results for All Possible Survey
Pairs Comparison Showing Depositional Observations
at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 20a

2010

P:\0285924\Mapping\CSM_MassBalance\bathy_simulation_deposition_v2.mxd



Legend

Area Subject to Erosion at 70% Confidence Level

Number of Deposition Observations at 70% Confidence Level



Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent
Shoreline as defined by the NJDEP



Conditional Simulation Results for All Possible Survey
Pairs Comparison Showing Depositional Observations
at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 20b

2010



Legend

- Area Subject to Erosion at 70% Confidence Level

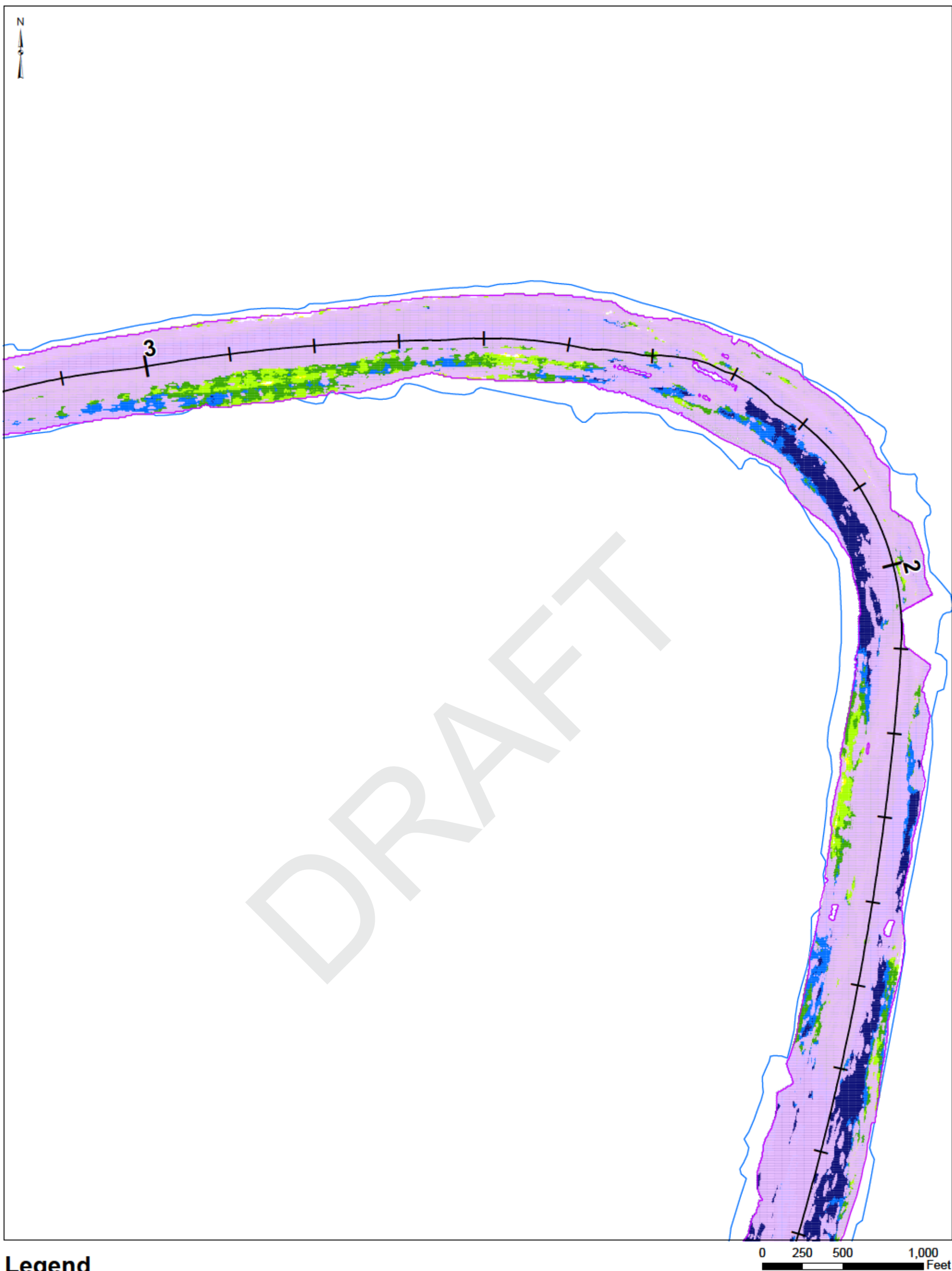
Number of Deposition Observations at 70% Confidence Level

1	2 to 8	9 to 15	16 to 22	≥ 23
---	--------	---------	----------	------

- Simulation Grid Extent
- Shoreline as defined by the NJDEP

Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

P:\0285924\Mapping\CSM_MassBalance\bathy_simulation_deposition_v2.mxd



Legend

Area Subject to Erosion at 70% Confidence Level

Number of Deposition Observations at 70% Confidence Level



Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent
Shoreline as defined by the NJDEP



Conditional Simulation Results for All Possible Survey
Pairs Comparison Showing Depositional Observations
at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 20d

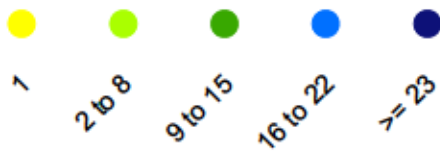
2010



Legend

Area Subject to Erosion at 70% Confidence Level

Number of Deposition Observations at 70% Confidence Level



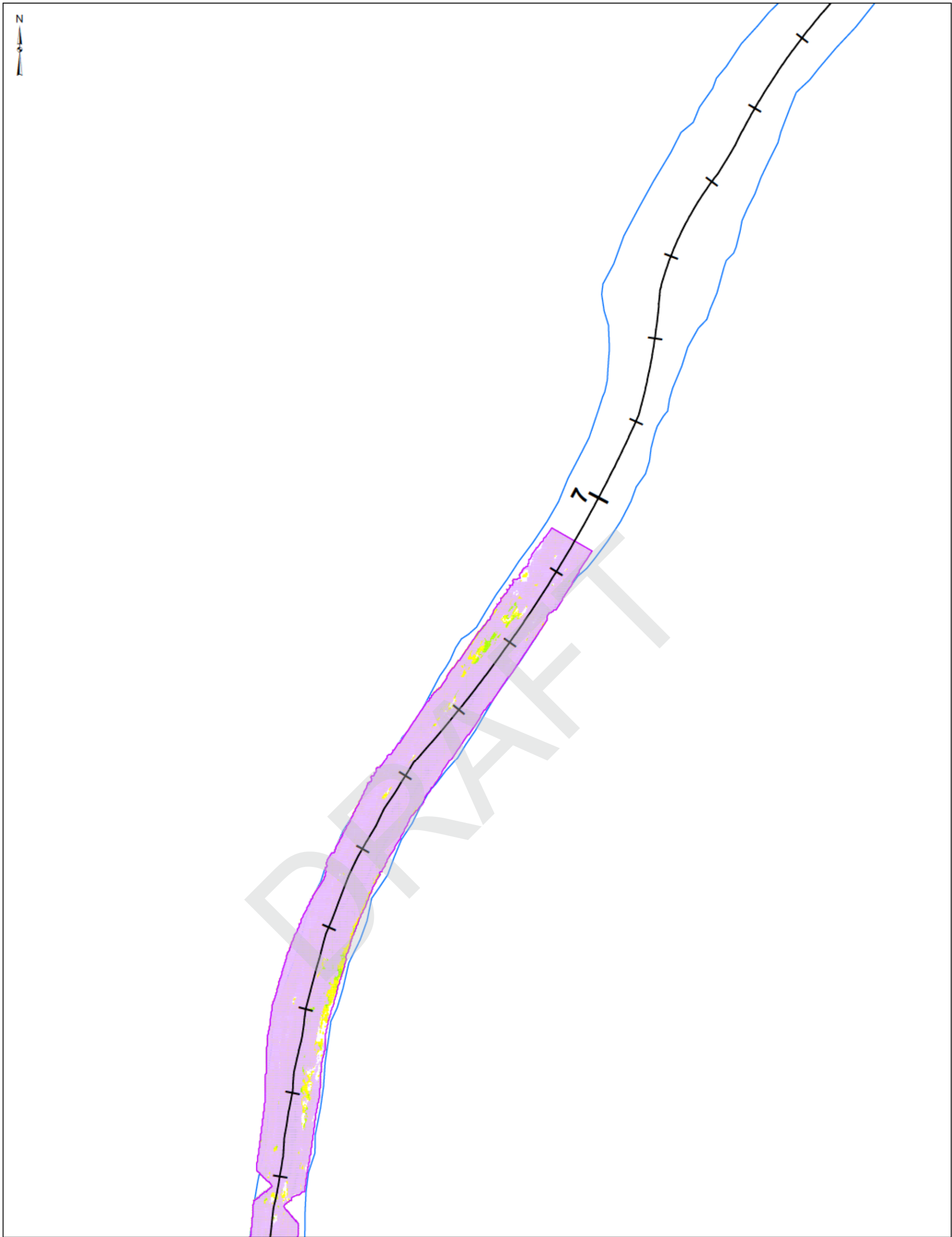
Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent
Shoreline as defined by the NJDEP



Conditional Simulation Results for All Possible Survey Pairs Comparison Showing Depositional Observations at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

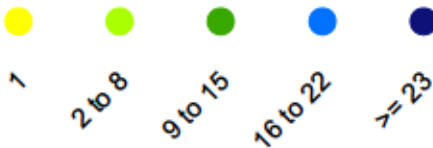
Figure 20e
2010



Legend

Area Subject to Erosion at 70% Confidence Level

Number of Deposition Observations at 70% Confidence Level



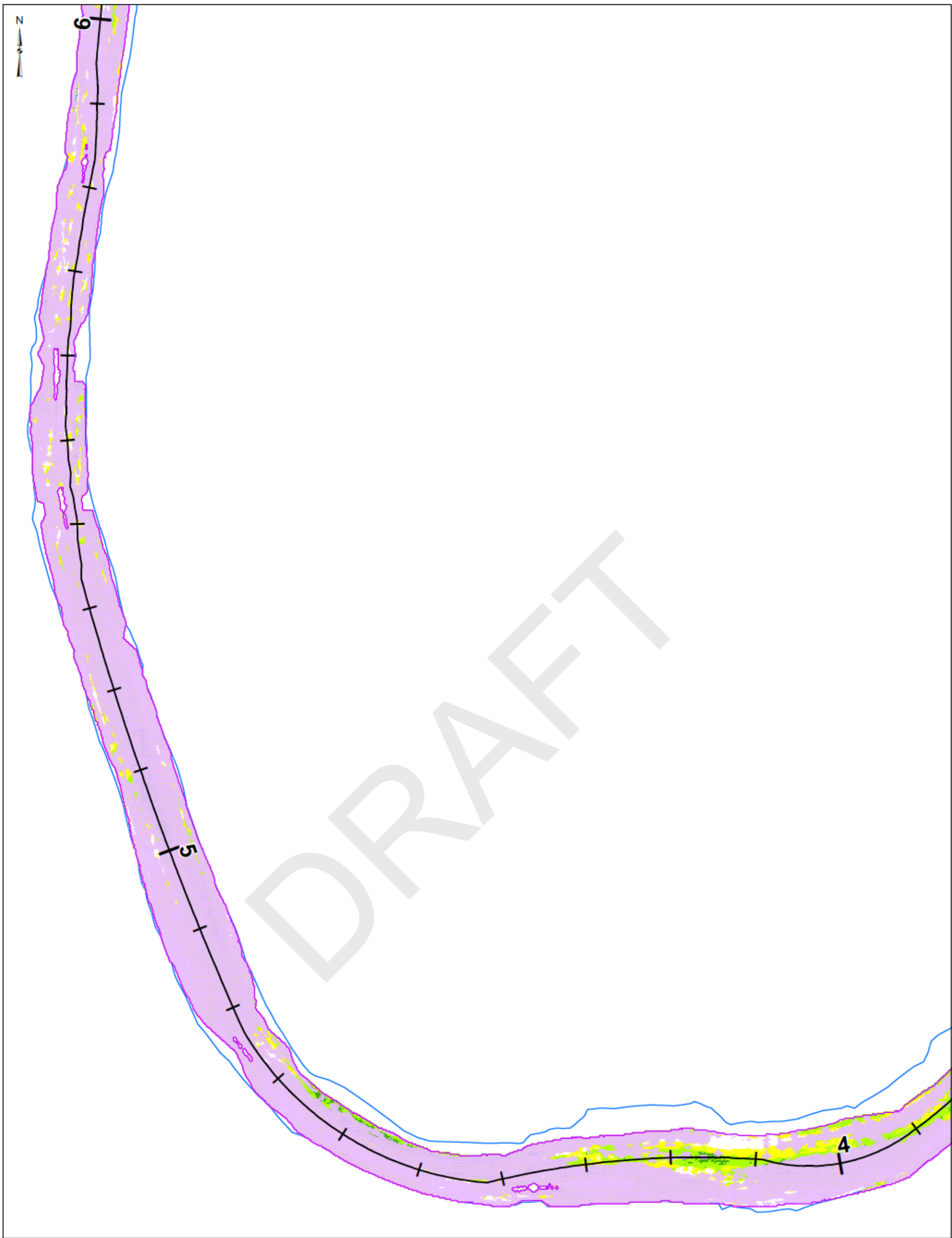
Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent
Shoreline as defined by the NJDEP



Conditional Simulation Results for Sequential Survey
Pairs Comparison Showing Depositional Observations
at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 21a
2010



Legend

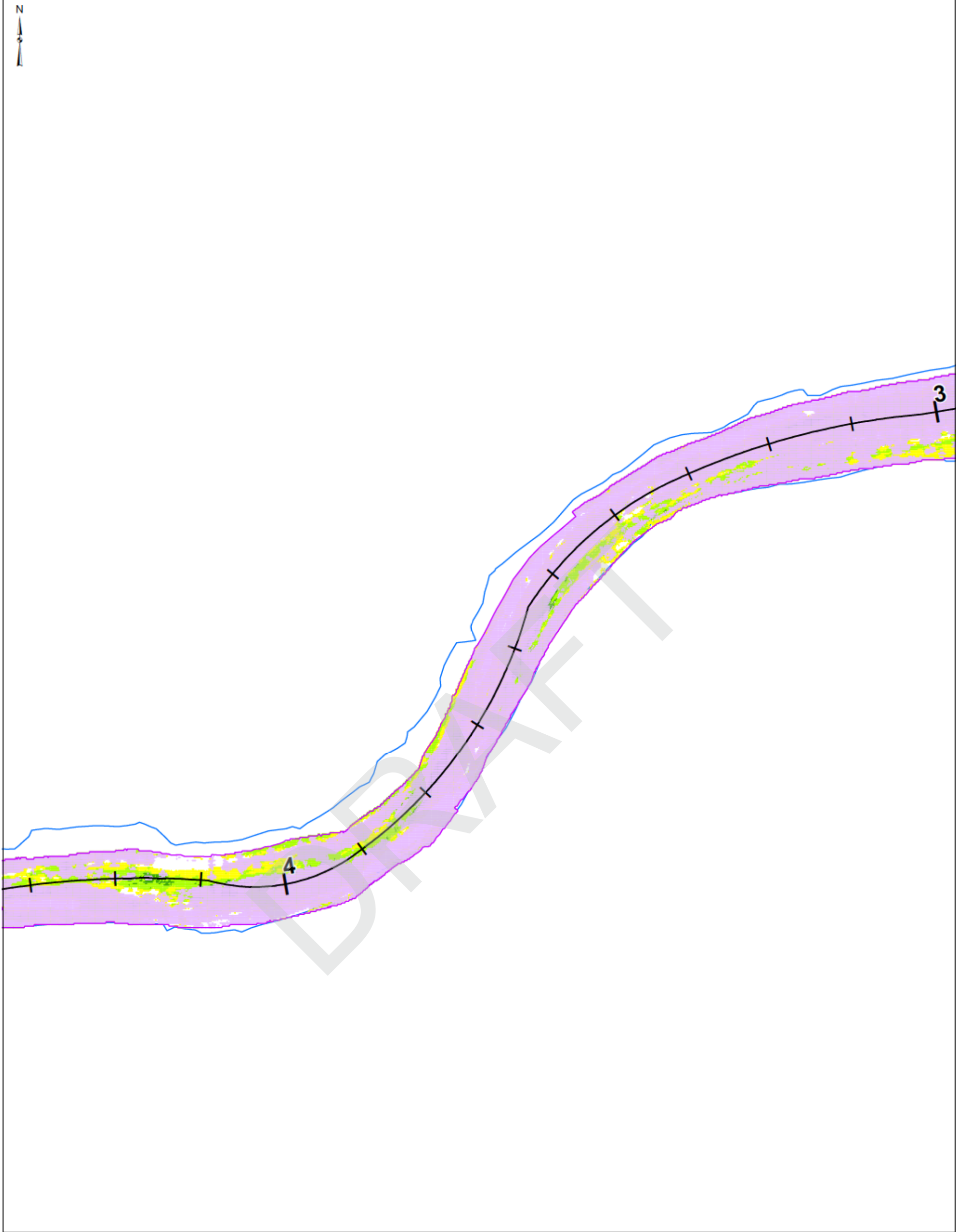
- Area Subject to Erosion at 70% Confidence Level
- Number of Deposition Observations at 70% Confidence Level
 - 1
 - 2 to 8
 - 9 to 15
 - 16 to 22
 - >= 23
- Simulation Grid Extent
- Shoreline as defined by the NJDEP

Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.



Conditional Simulation Results for Sequential Survey Pairs Comparison Showing Depositional Observations at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 21b
2010



Legend

- Area Subject to Erosion at 70% Confidence Level
- Number of Deposition Observations at 70% Confidence Level
 - 1
 - 2 to 8
 - 9 to 15
 - 16 to 22
 - >= 23

Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

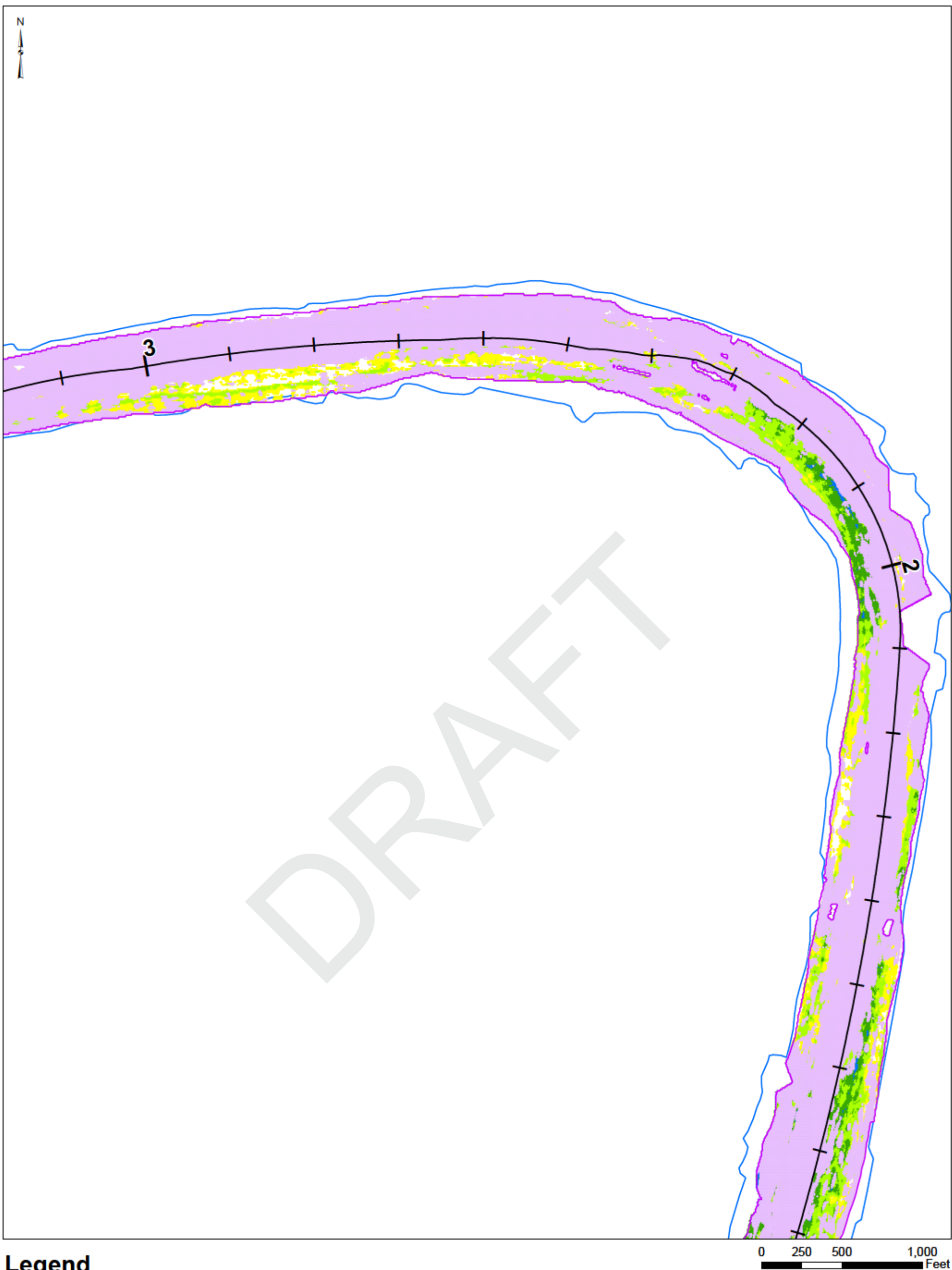
- Simulation Grid Extent
- Shoreline as defined by the NJDEP



Conditional Simulation Results for Sequential Survey Pairs Comparison Showing Depositional Observations at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 21c
2010

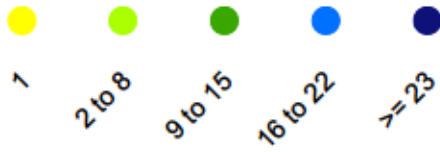
P:\0285924\Mapping\CSM_MassBalance\bathy_simulation_deposition_v2.mxd



Legend

Area Subject to Erosion at 70% Confidence Level

Number of Deposition Observations at 70% Confidence Level



Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

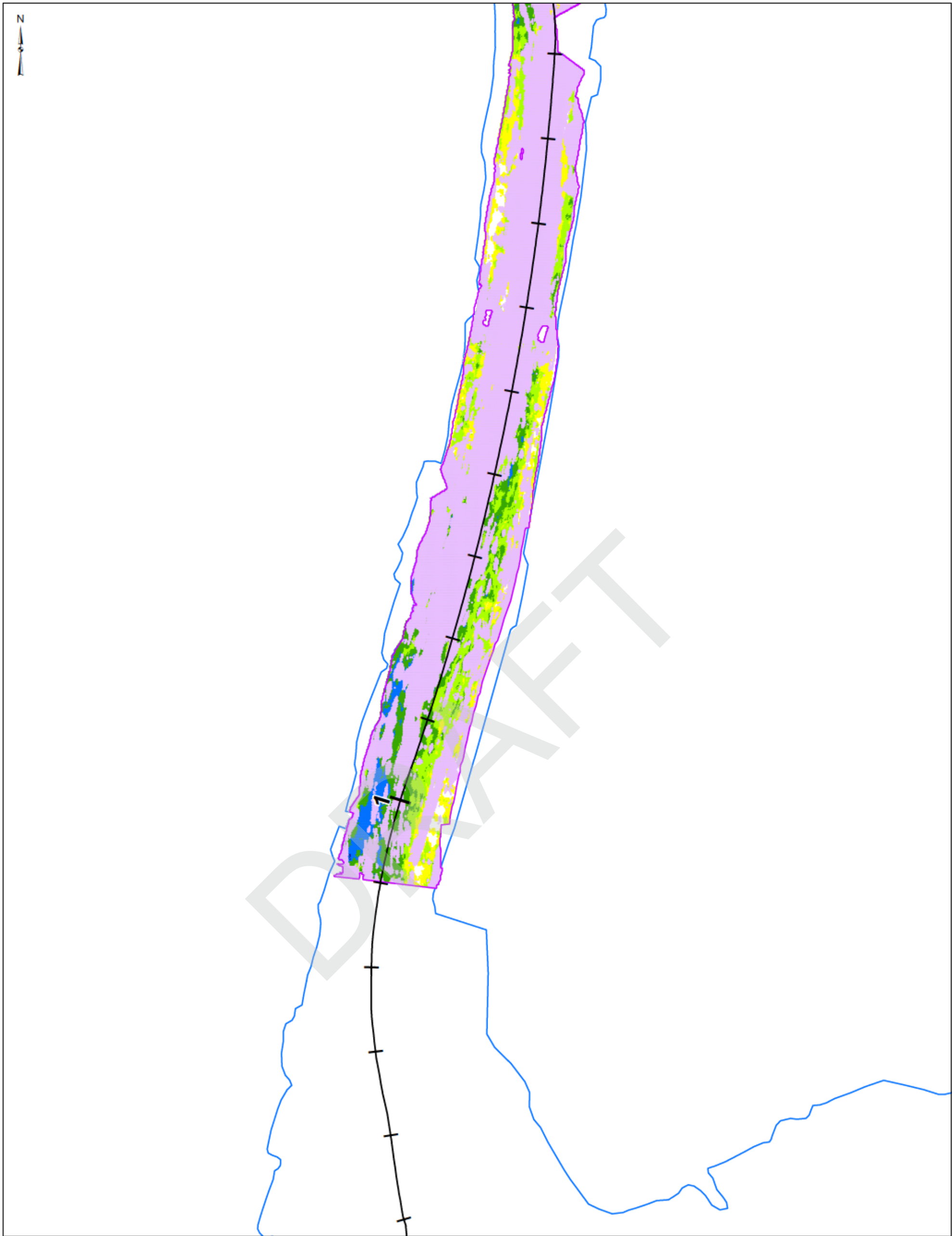
Simulation Grid Extent
Shoreline as defined by the NJDEP



Conditional Simulation Results for Sequential Survey
Pairs Comparison Showing Depositional Observations
at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 21d

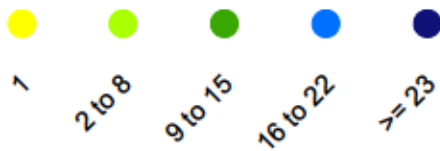
2010



Legend

Area Subject to Erosion at 70% Confidence Level

Number of Deposition Observations at 70% Confidence Level



Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent
Shoreline as defined by the NJDEP

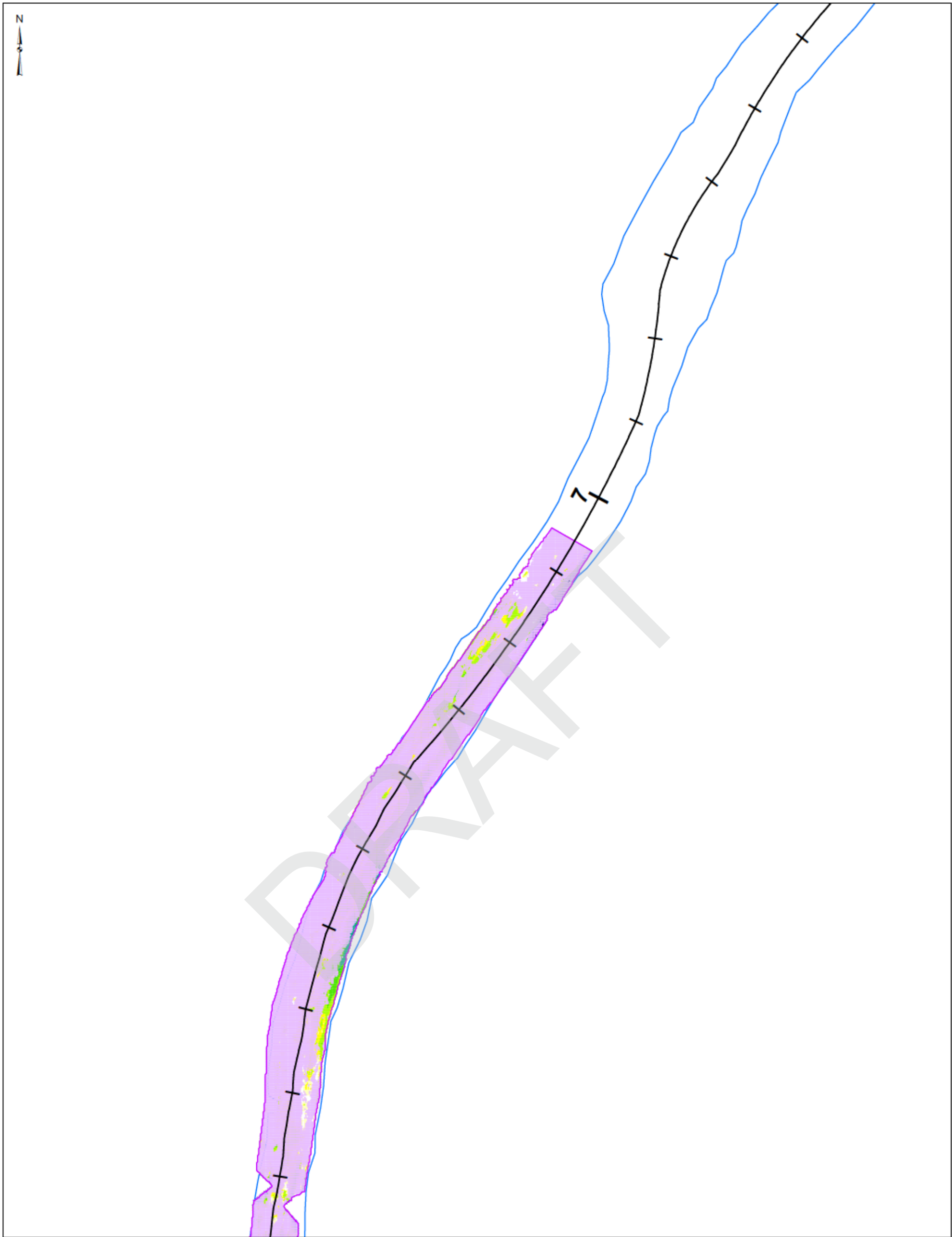


Conditional Simulation Results for Sequential Survey
Pairs Comparison Showing Depositional Observations
at a Minimum 70% Level of Confidence in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 21e

2010

P:\0285924\Mapping\CSM_MassBalance\bathy_simulation_deposition_v2.mxd



Legend

- Area Subject to Erosion at 70% Confidence Level
- Long Term (1989 to 2007) Elevation Change (ft)
- ≤ 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 7 - 6

Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent

Shoreline as defined by the NJDEP

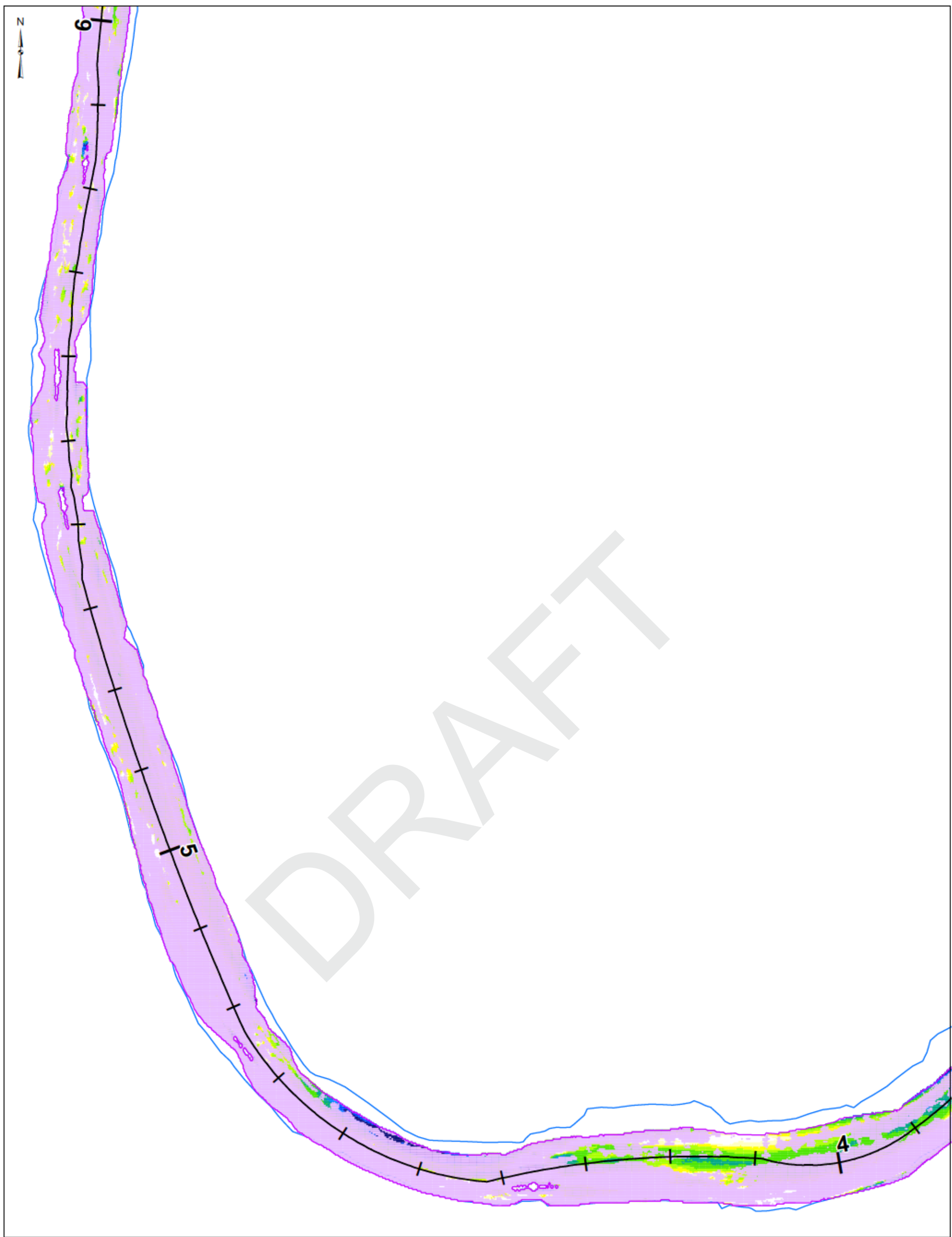
0 250 500 1,000 Feet



Conditional Simulation Results for All Possible
Survey Pairs Comparison Showing Long Term (1989-2007)
Elevation Changes in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 22a
2010

P:\0285924\Mapping\CSM_MassBalance\bathy_simulation_deposition_v2.mxd



Legend

- Area Subject to Erosion at 70% Confidence Level
- Long Term (1989 to 2007) Elevation Change (ft)
- ≤0.5
- 0.5-1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- >6

Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent

Shoreline as defined by the NJDEP

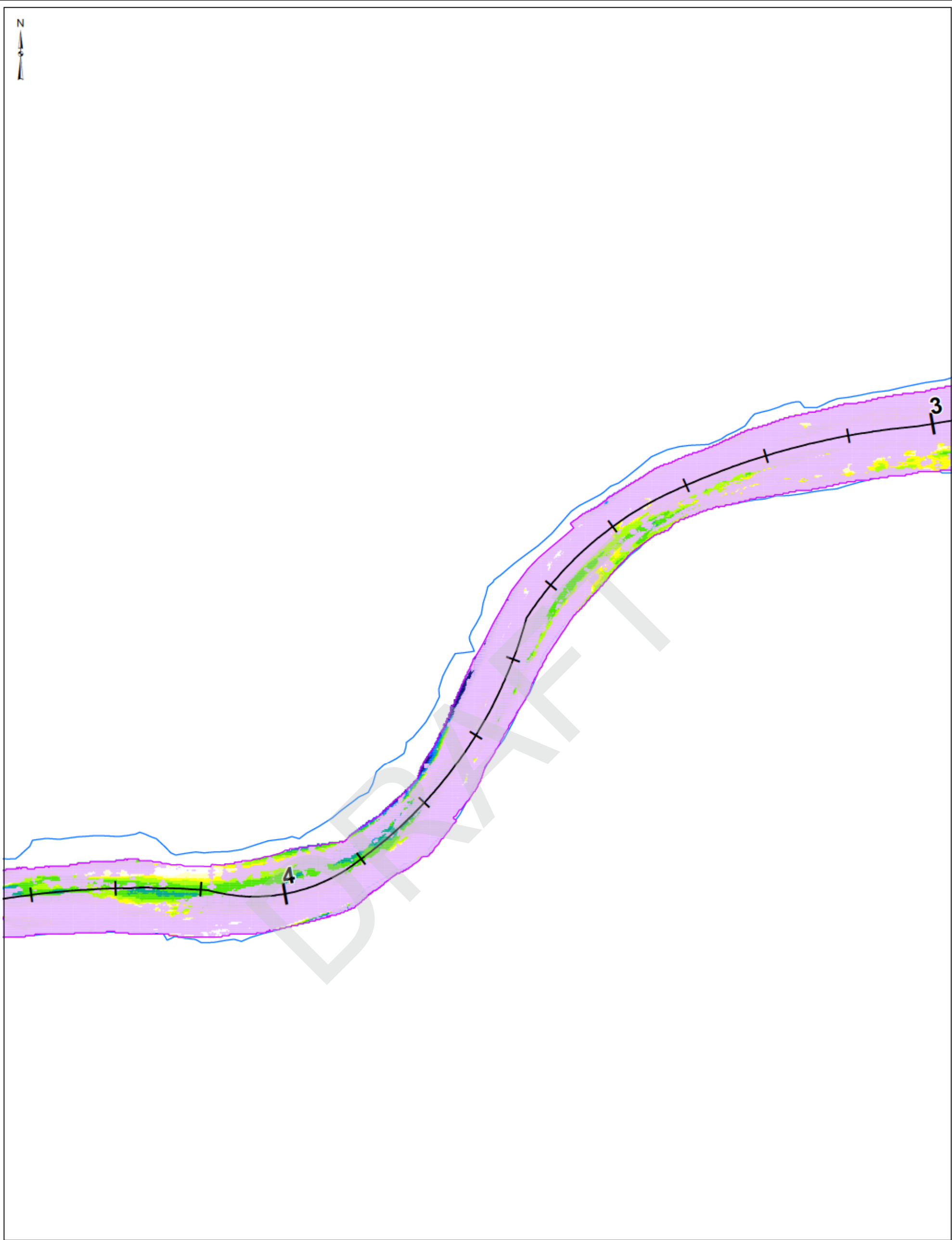
0 250 500 1,000 Feet



Conditional Simulation Results for All Possible Survey Pairs Comparison Showing Long Term (1989-2007) Elevation Changes in Non-Significant Erosion Areas Lower Passaic River Restoration

Figure 22b 2010

P:\0285924\Mapping\CSM_MassBalance\bathy_simulation_deposition_v2.mxd



Legend

- Area Subject to Erosion at 70% Confidence Level
- Long Term (1989 to 2007) Elevation Change (ft)
 - ≤ 0.5
 - 0.5-1
 - 1-2
 - 2-3
 - 3-4
 - 4-5
 - 5-6
 - 7-6

Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

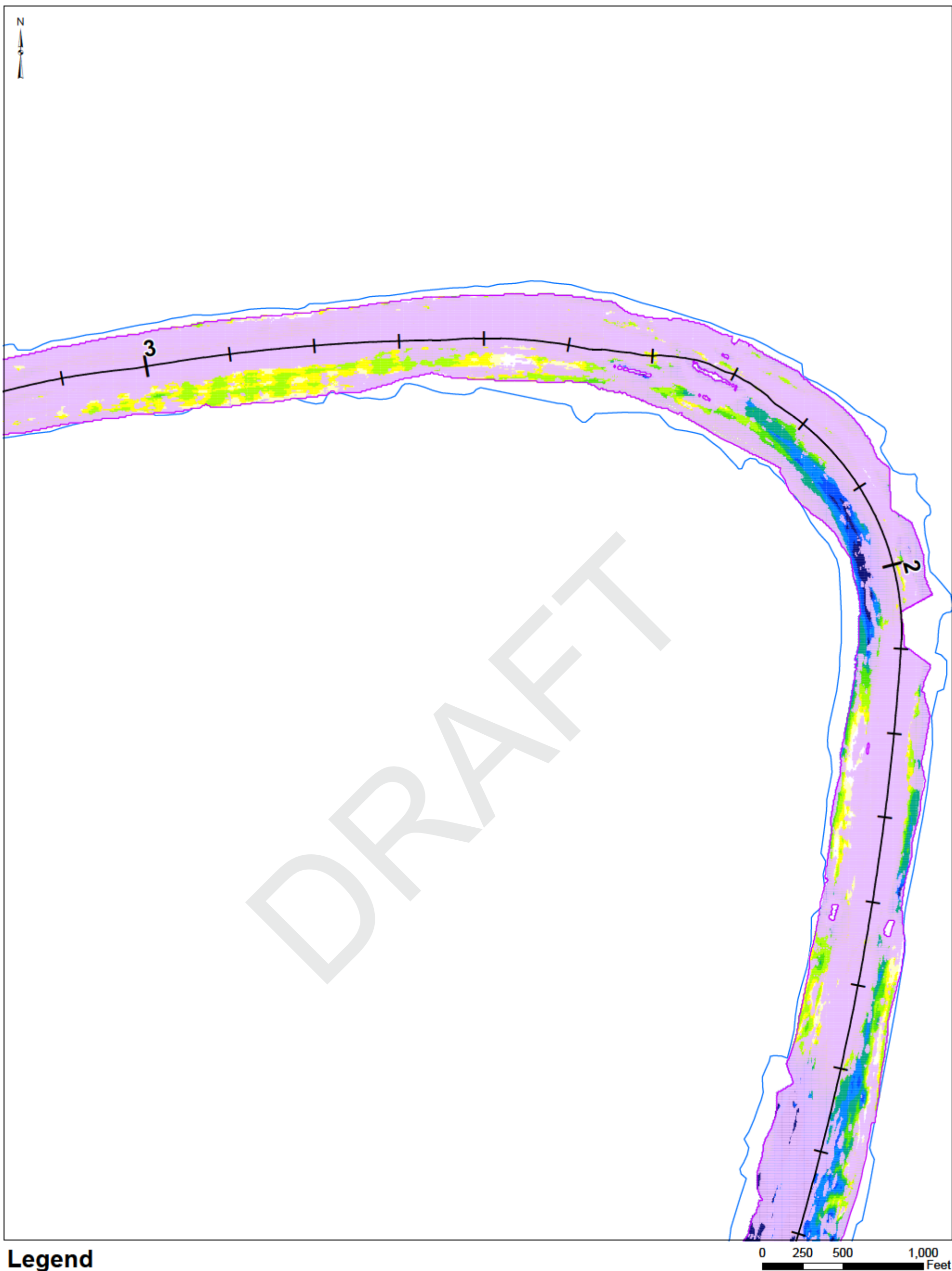
- Simulation Grid Extent
- Shoreline as defined by the NJDEP



Conditional Simulation Results for All Possible
Survey Pairs Comparison Showing Long Term (1989-2007)
Elevation Changes in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 22c
2010

P:\0285924\Mapping\CSM_MassBalance\bathy_simulation_deposition_v2.mxd



Legend

- Area Subject to Erosion at 70% Confidence Level
- Long Term (1989 to 2007) Elevation Change (ft)
- ≤0.5
- 0.5-1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- ≥6

Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

- Simulation Grid Extent
- Shoreline as defined by the NJDEP



Conditional Simulation Results for All Possible
Survey Pairs Comparison Showing Long Term (1989-2007)
Elevation Changes in Non-Significant Erosion Areas
Lower Passaic River Restoration

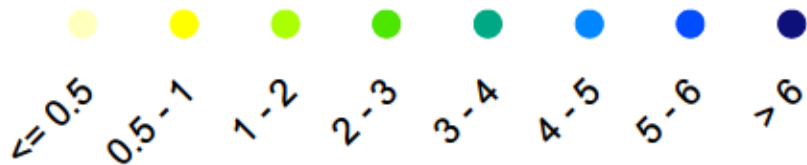
Figure 22d
2010



Legend

Area Subject to Erosion at 70% Confidence Level

Long Term (1989 to 2007) Elevation Change (ft)



Note: The white areas within the simulation grid extent represents area where no erosional events were observed at a 70% level of confidence. These areas also had no observations of deposition with a 70% level of confidence.

Simulation Grid Extent
Shoreline as defined by the NJDEP



Conditional Simulation Results for All Possible
Survey Pairs Comparison Showing Long Term (1989-2007)
Elevation Changes in Non-Significant Erosion Areas
Lower Passaic River Restoration

Figure 22e

2010

Figure & a: Single-Beam Elevation Difference at Survey Line Crossings, 2007
Cross Flow Transect Elevation vs. Longitudinal Transect Elevation

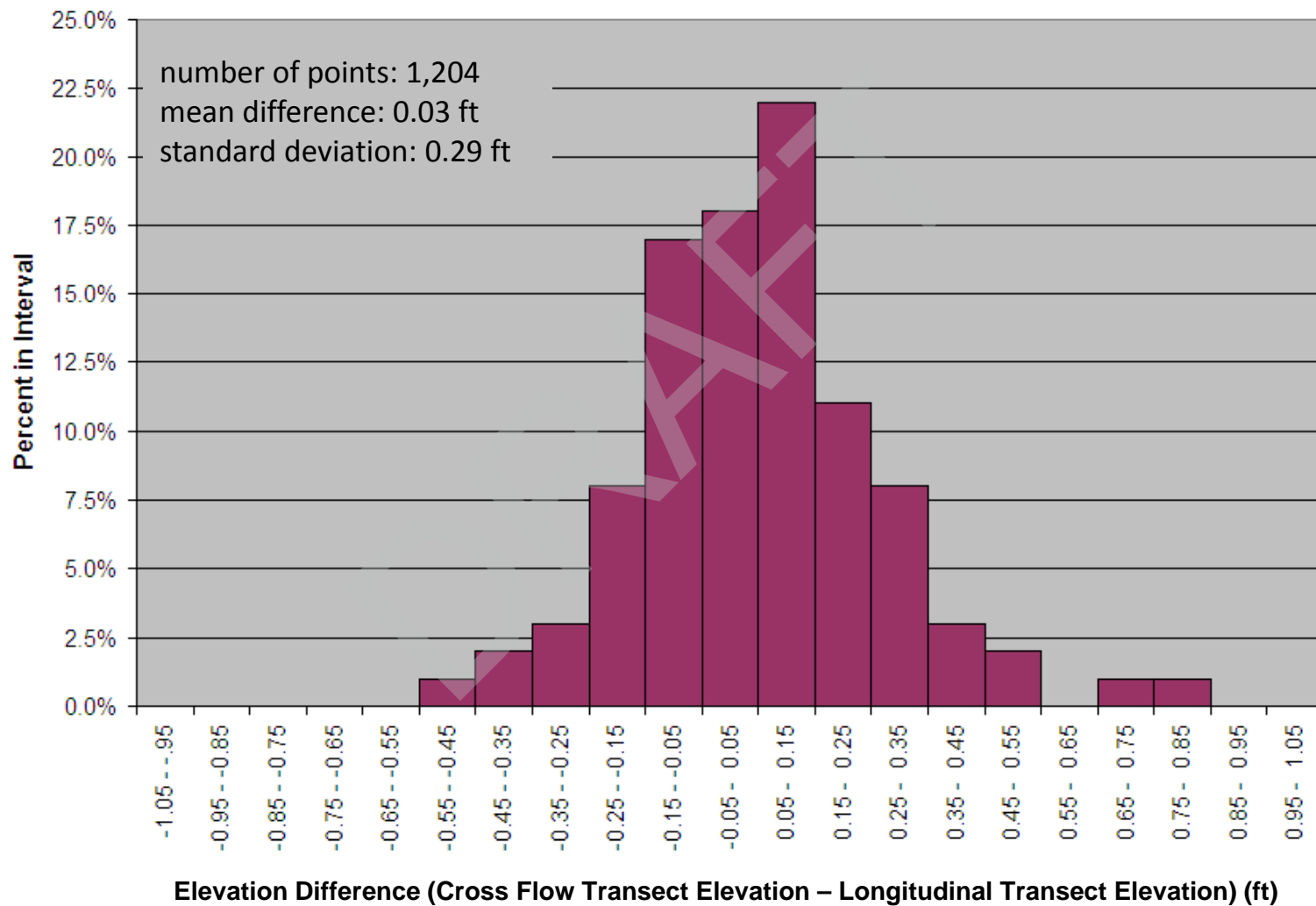


Figure 23b Histogram of 2007 Multibeam - 2007 Single Beam Cross Transects

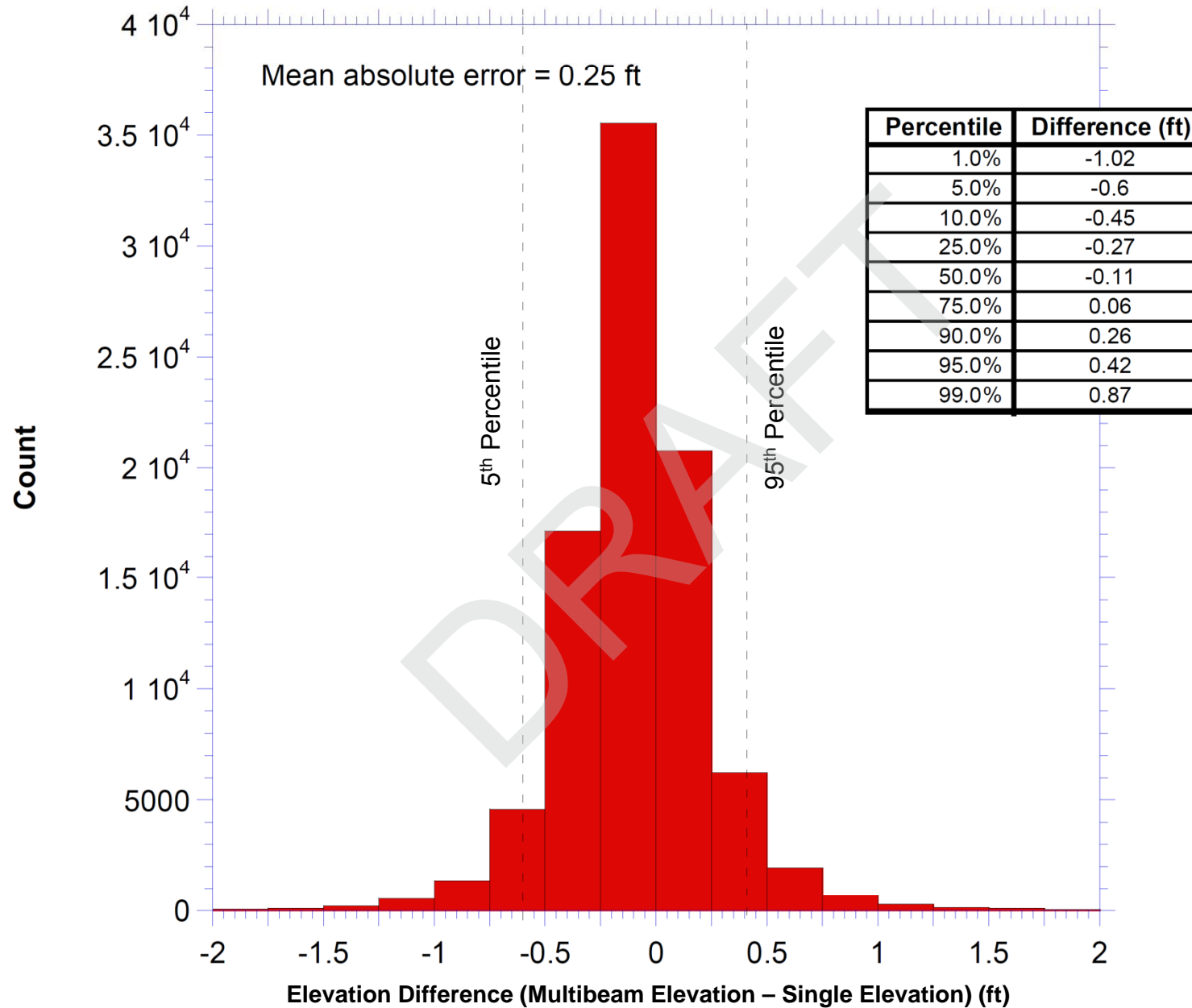
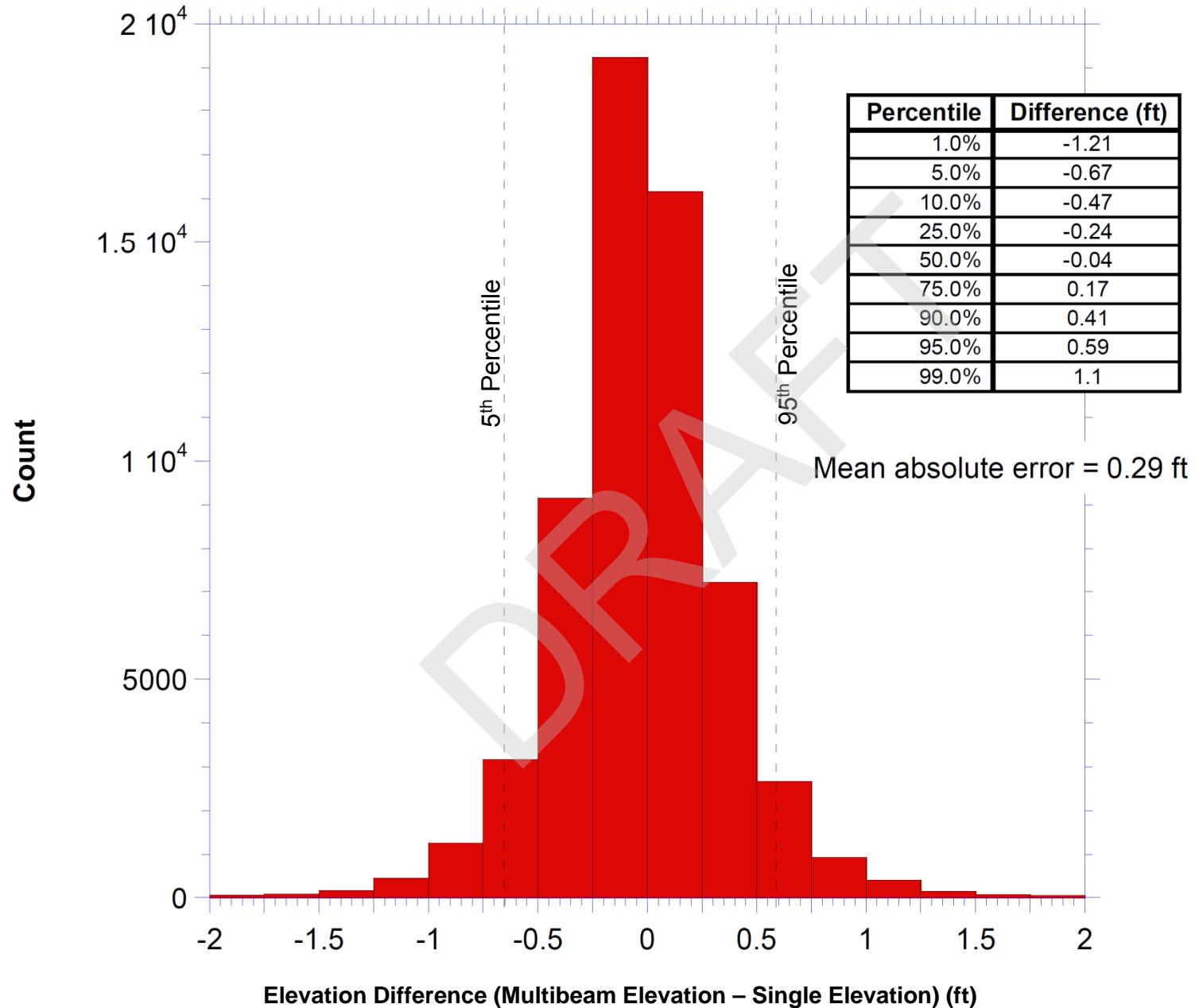
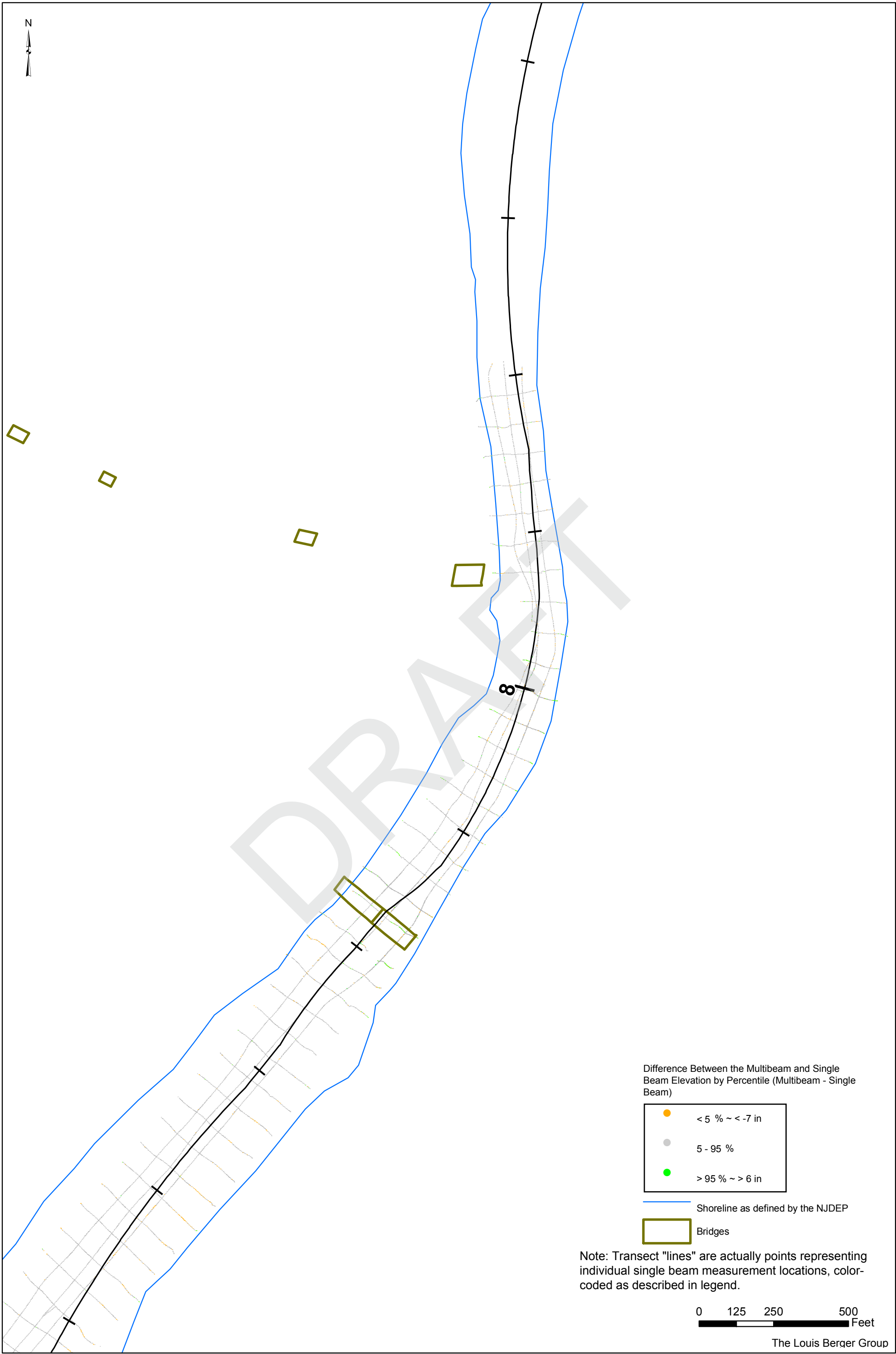


Figure 23c Histogram of 2007 Multibeam - 2007 Single Beam Longitudinal Transects



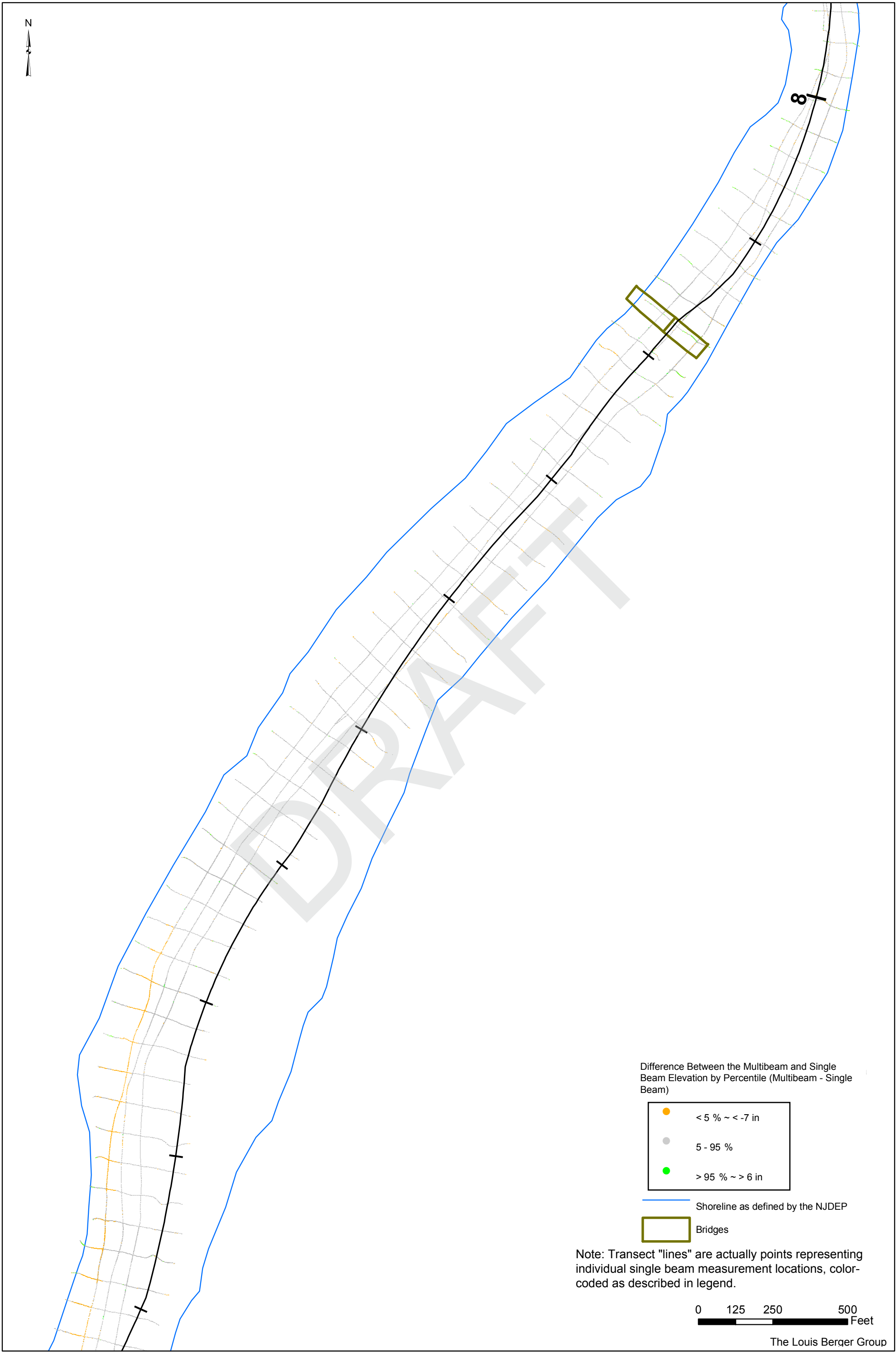


Comparison of the MultiBeam and Single Beam Surveys

Lower Passaic River Restoration Project

Figure 24a

I 2010

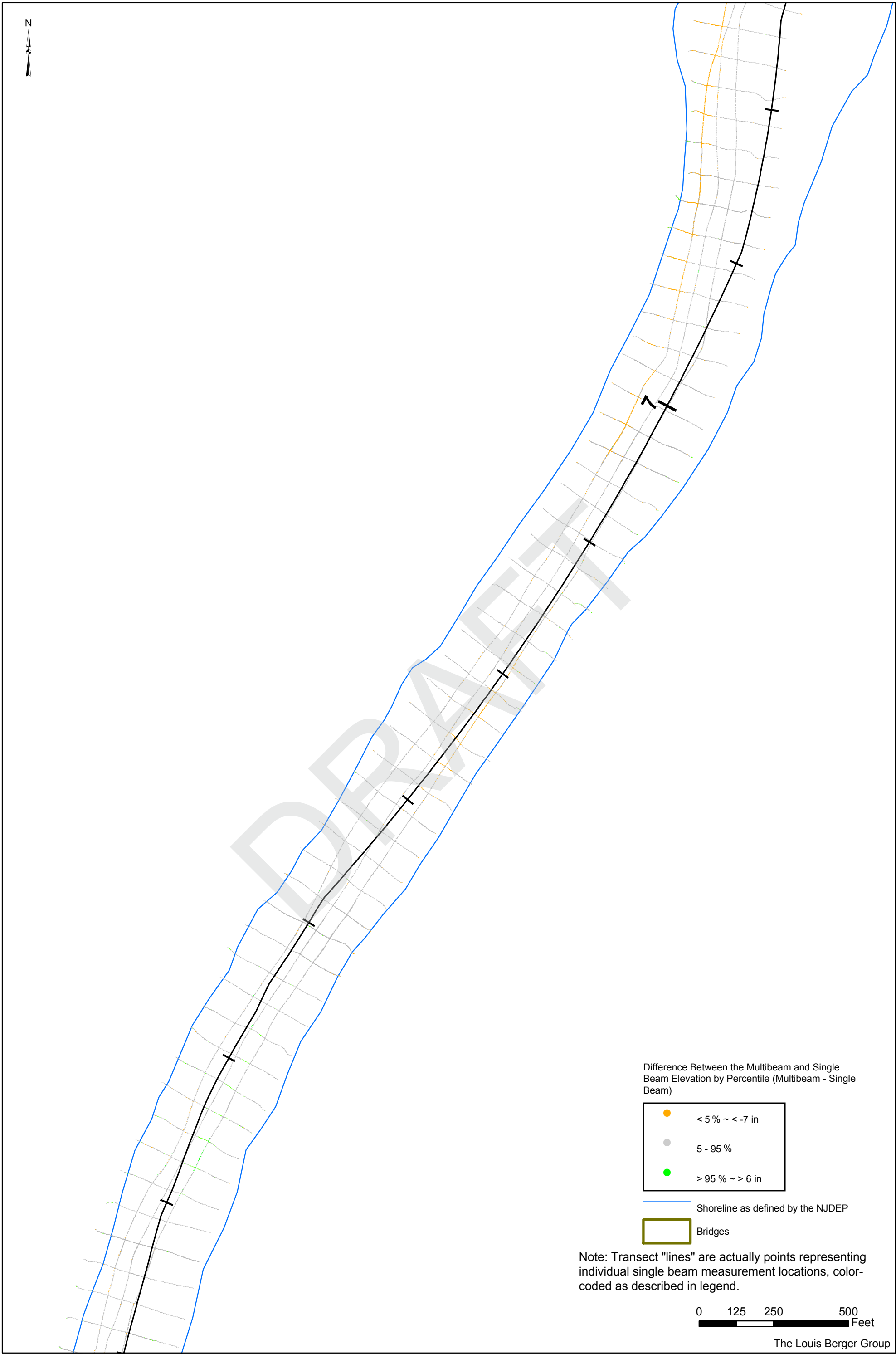


Comparison of the MultiBeam and Single Beam Surveys

Lower Passaic River Restoration Project

Figure 24b

2010

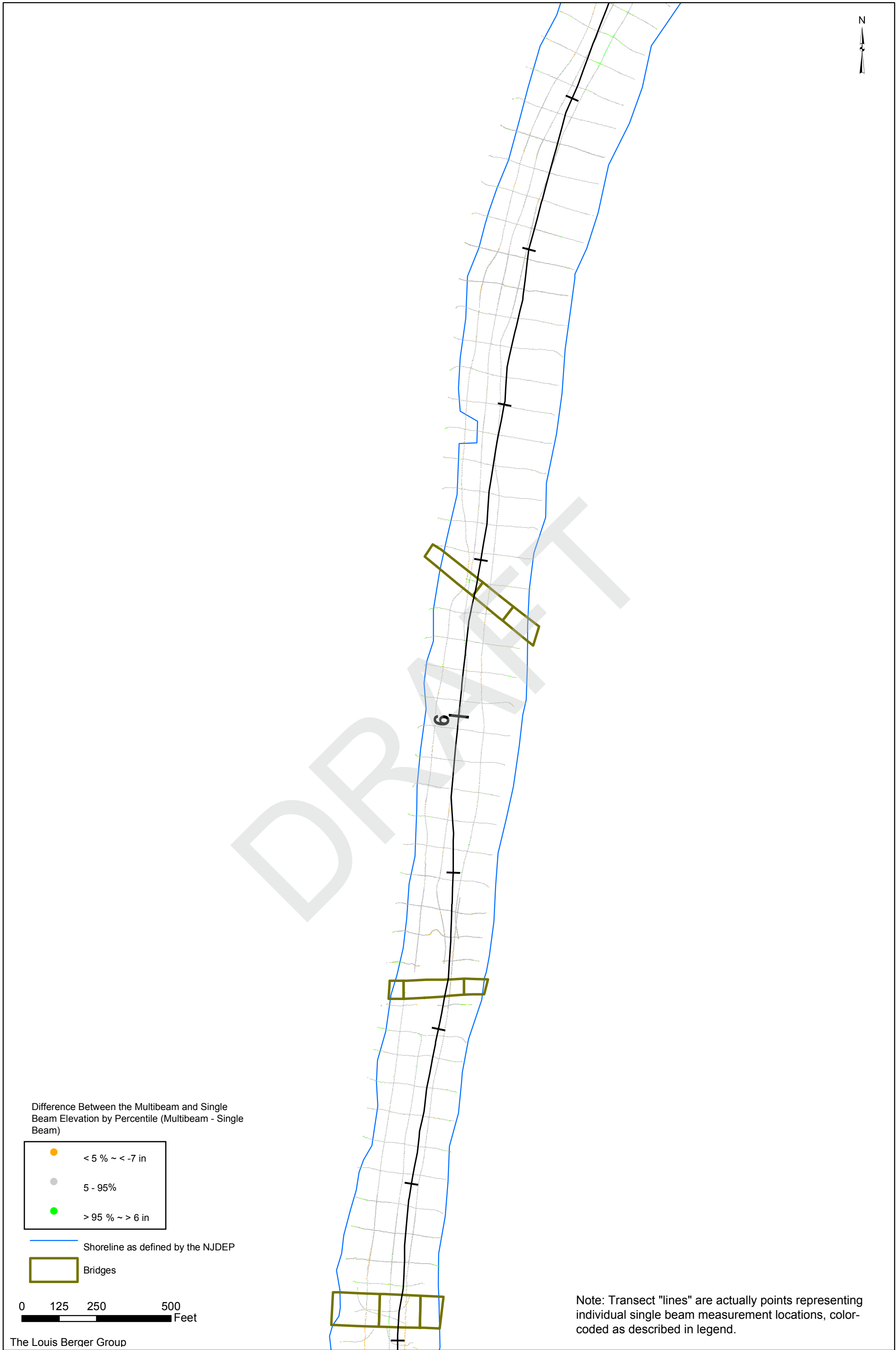


Comparison of the MultiBeam and Single Beam Surveys

Lower Passaic River Restoration Project

Figure 24c

2010

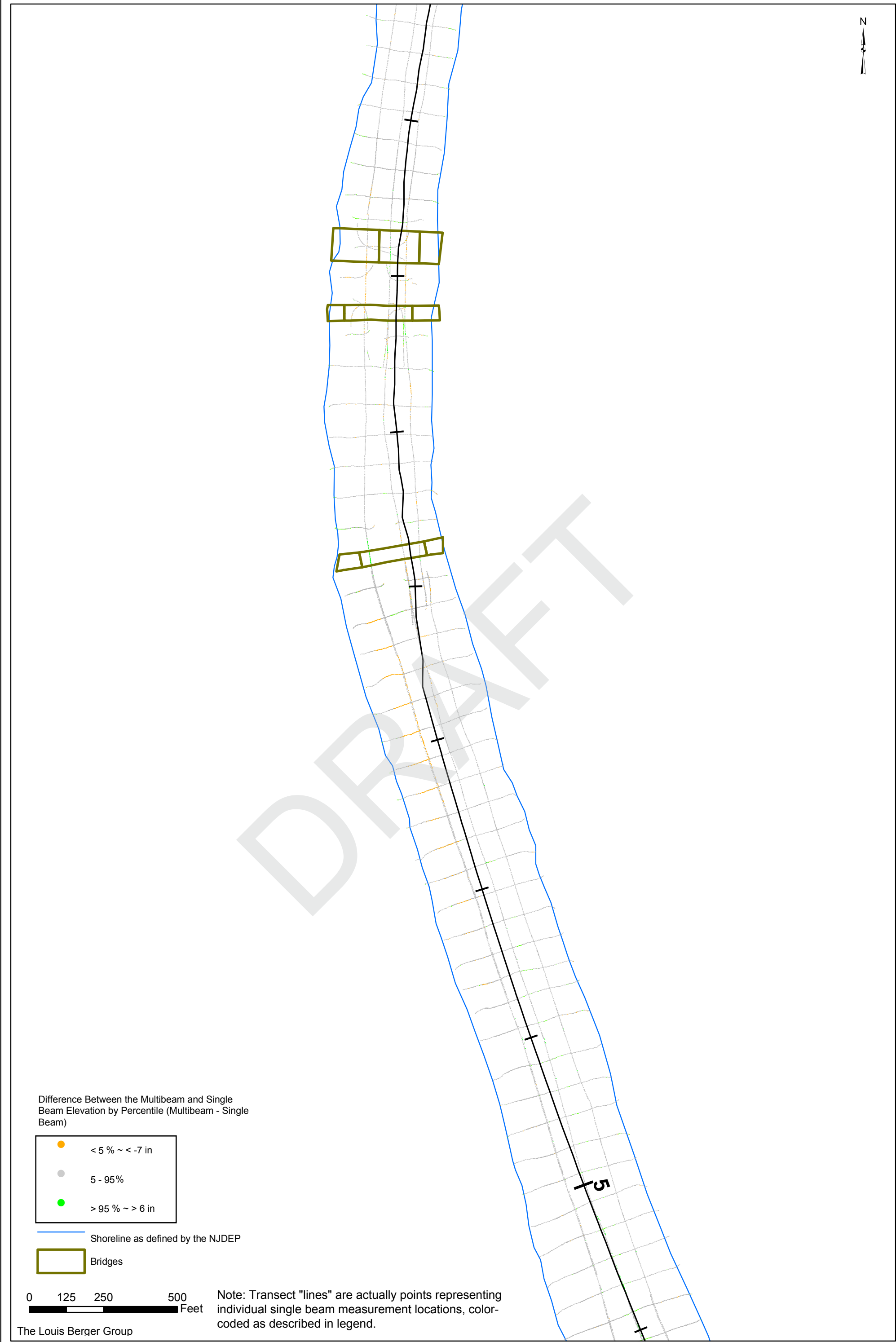


Comparison of the MultiBeam and Single Beam Surveys

Lower Passaic River Restoration Project

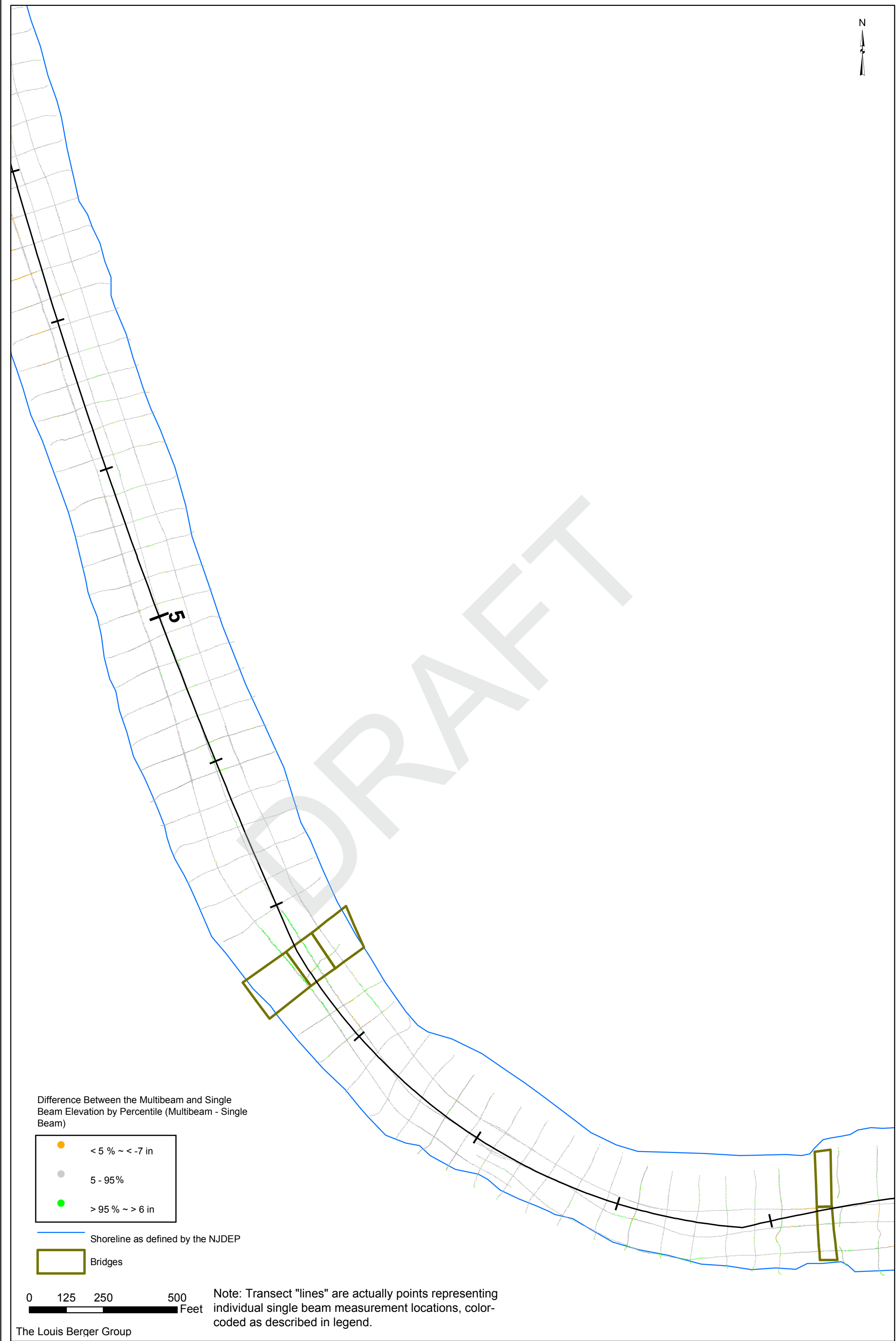
Figure 24d

2010



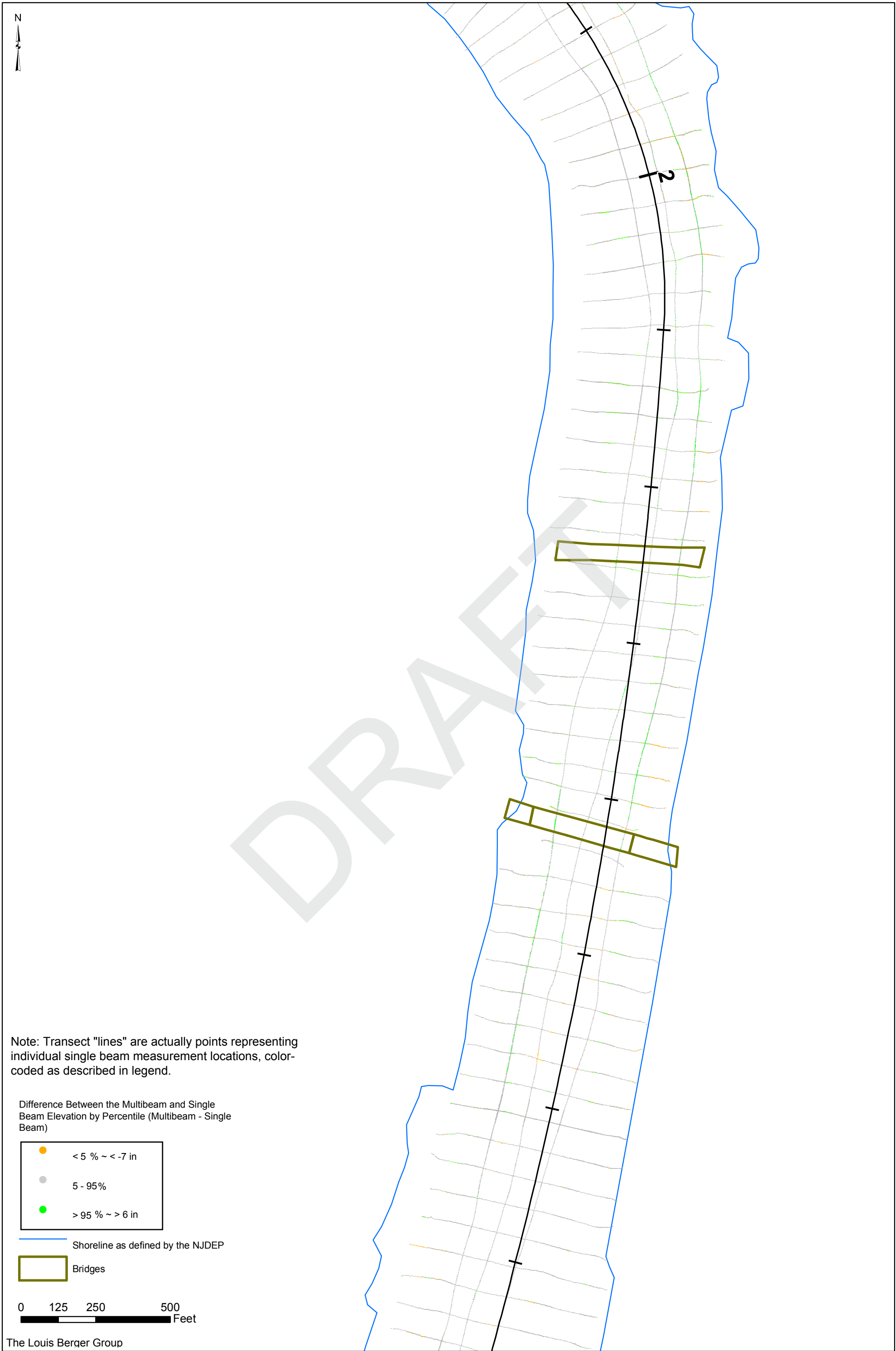
Comparison of the MultiBeam and Single Beam Surveys
Lower Passaic River Restoration Project

Figure 24e
2010





Comparison of the MultiBeam and Single Beam Surveys
Lower Passaic River Restoration Project



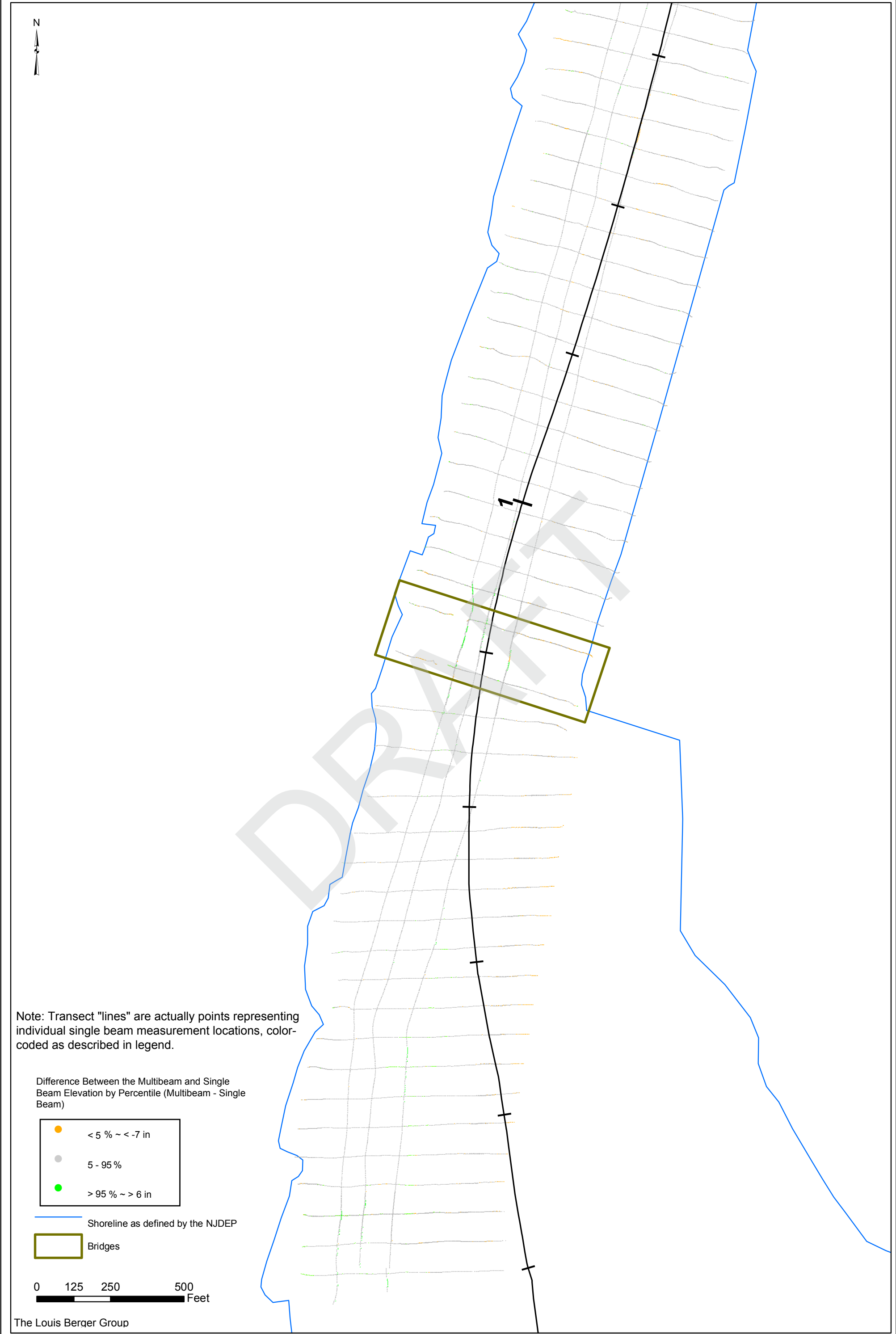


Figure 25: ADCP Mooring M2b (file PASS2001)

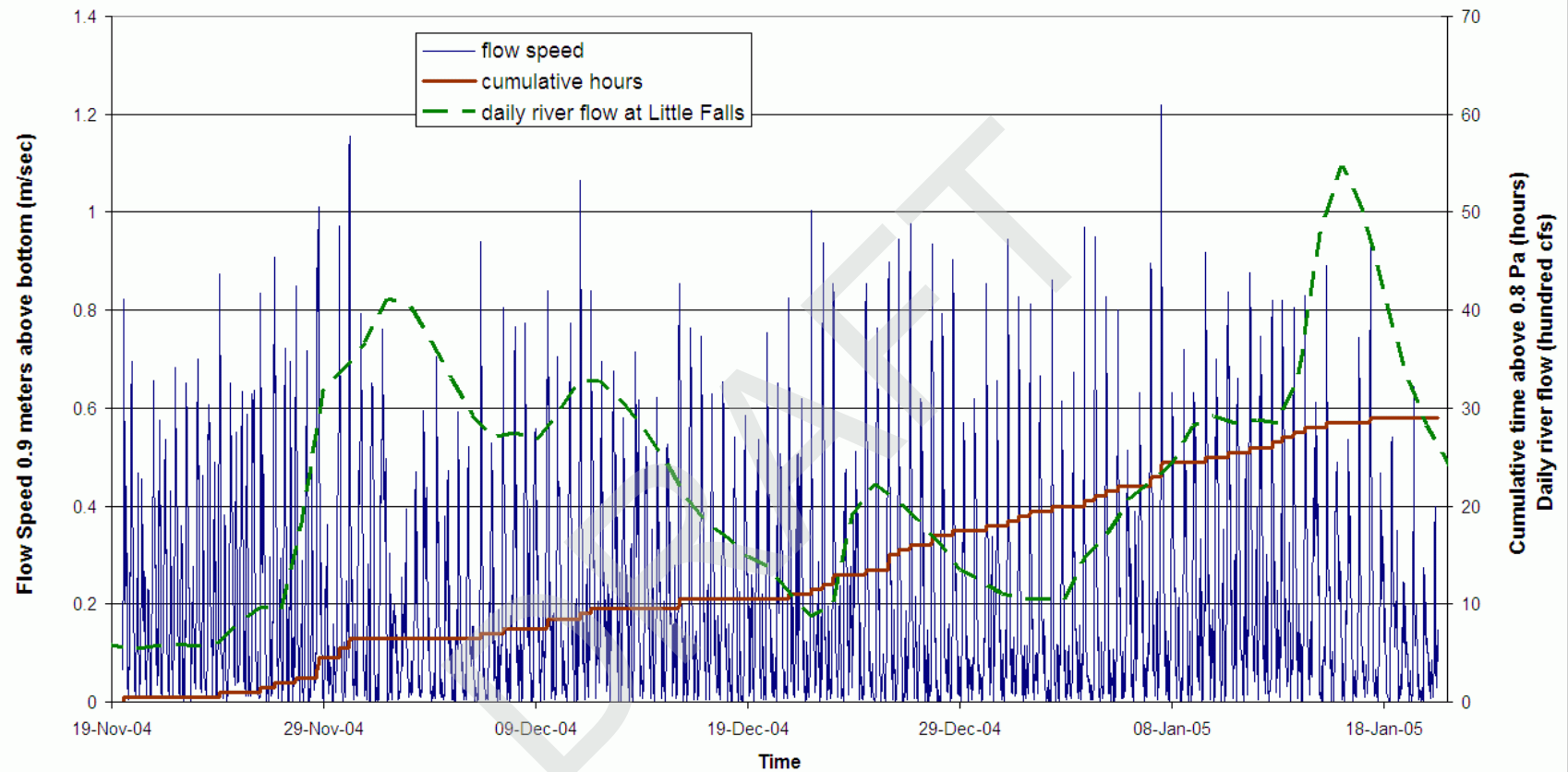


Figure 26a: Conditional Simulation Validation:
Difference between 2007 Actual Multibeam Surface
and Predicted 2007 Surface

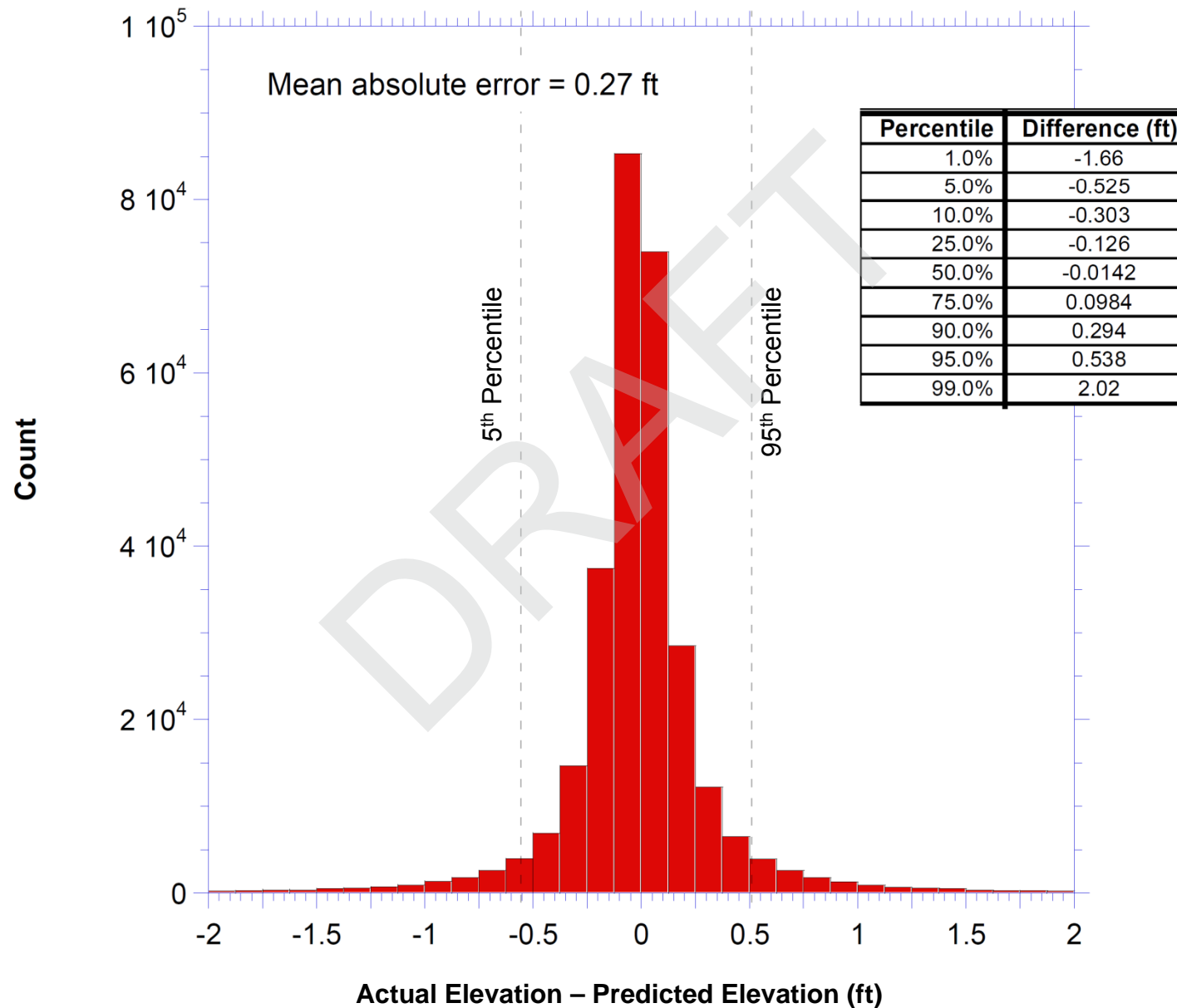
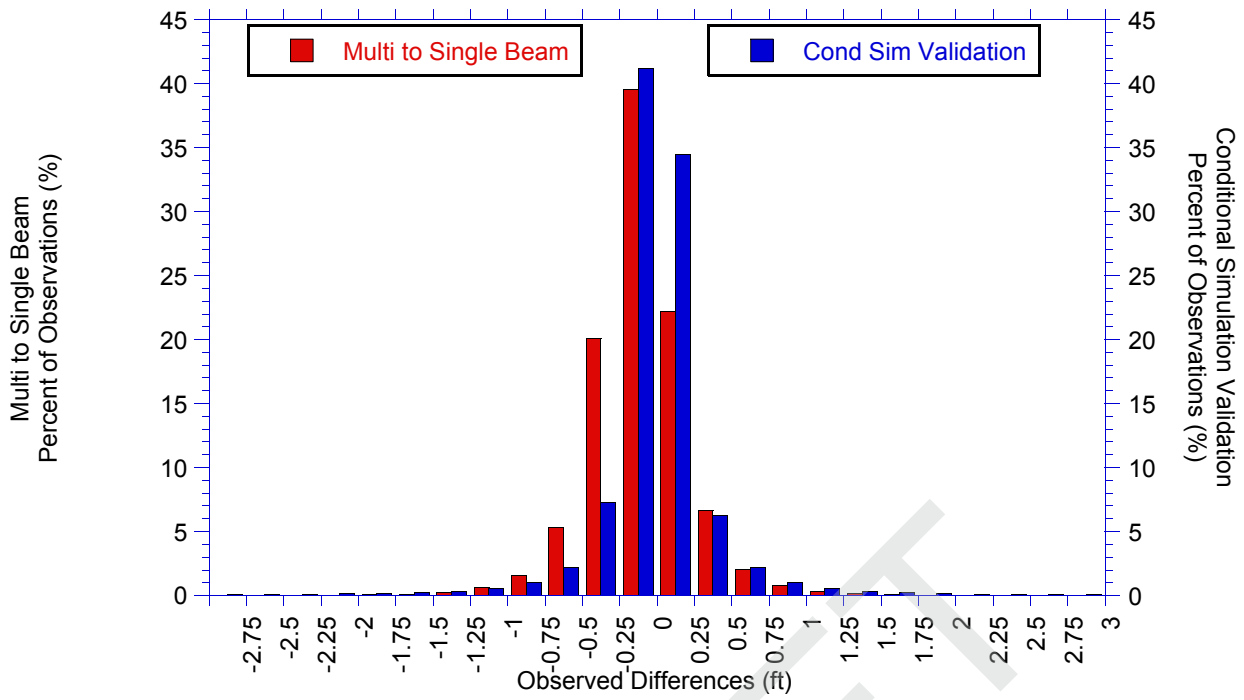


Figure 26b: Passaic Bathymetric Change Observations

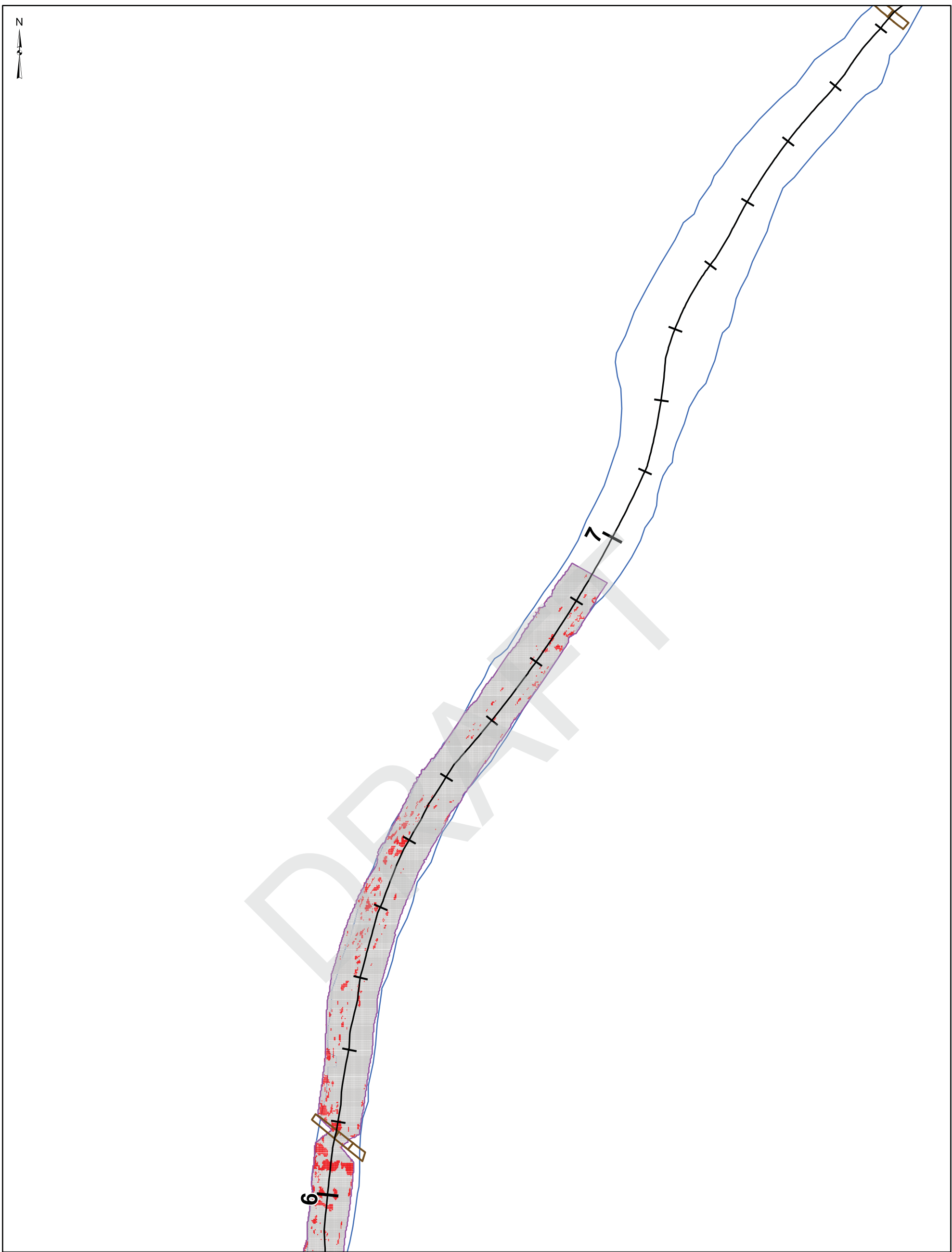


DRAFT

Figure : Conditional Simulation Validation False Positive rates

2007 Multibeam Surface Approximated by the 1995 Locations
via Conditional Simulation

Threshold	P(Erode>12-in)	P(Erode>6 in)	P(Erode>3 in)	P(Erode>0 in)
>31% probability	5%			
>50% probability	2.09%	5.23%	12%	49.7%
>62.5% Probability			5%	
>70% probability	1.178%	2.156%	3.367%	6.556%
>74% probability				5%



Legend

Probability of Occurrence
of at Least 6-inch Erosional Event

- < 0.5
- >= 0.5

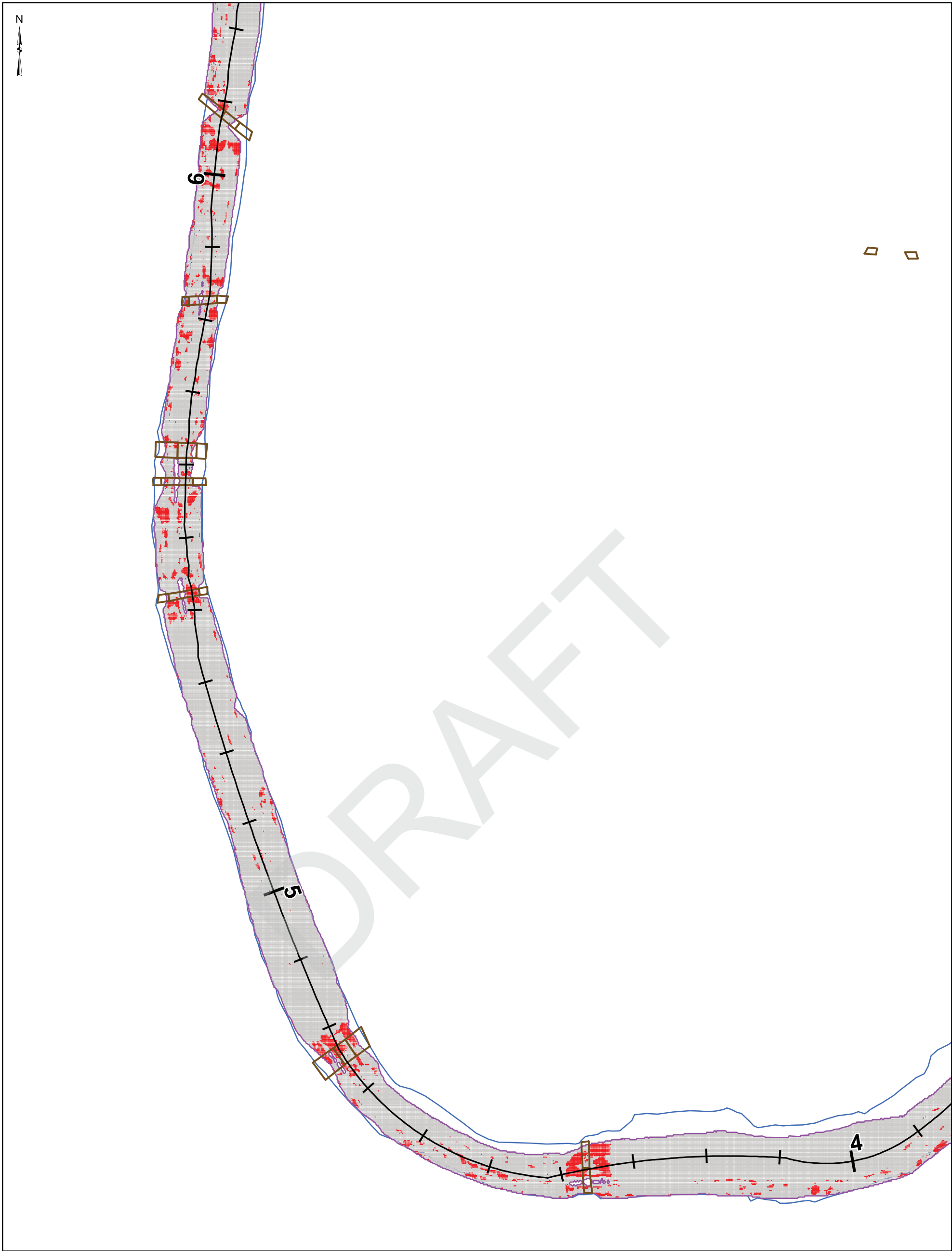
- Simulation Grid Extent
- Shoreline as defined by the NJDEP
- Bridges



Conditional Simulation Validation Results
Distribution of False Positives
Prediction of 6 inches of Erosion
Lower Passaic River Restoration Project

Figure 28a

2010



Legend

Probability of Occurrence of at Least 6-inch Erosional Event

- < 0.5
- >= 0.5

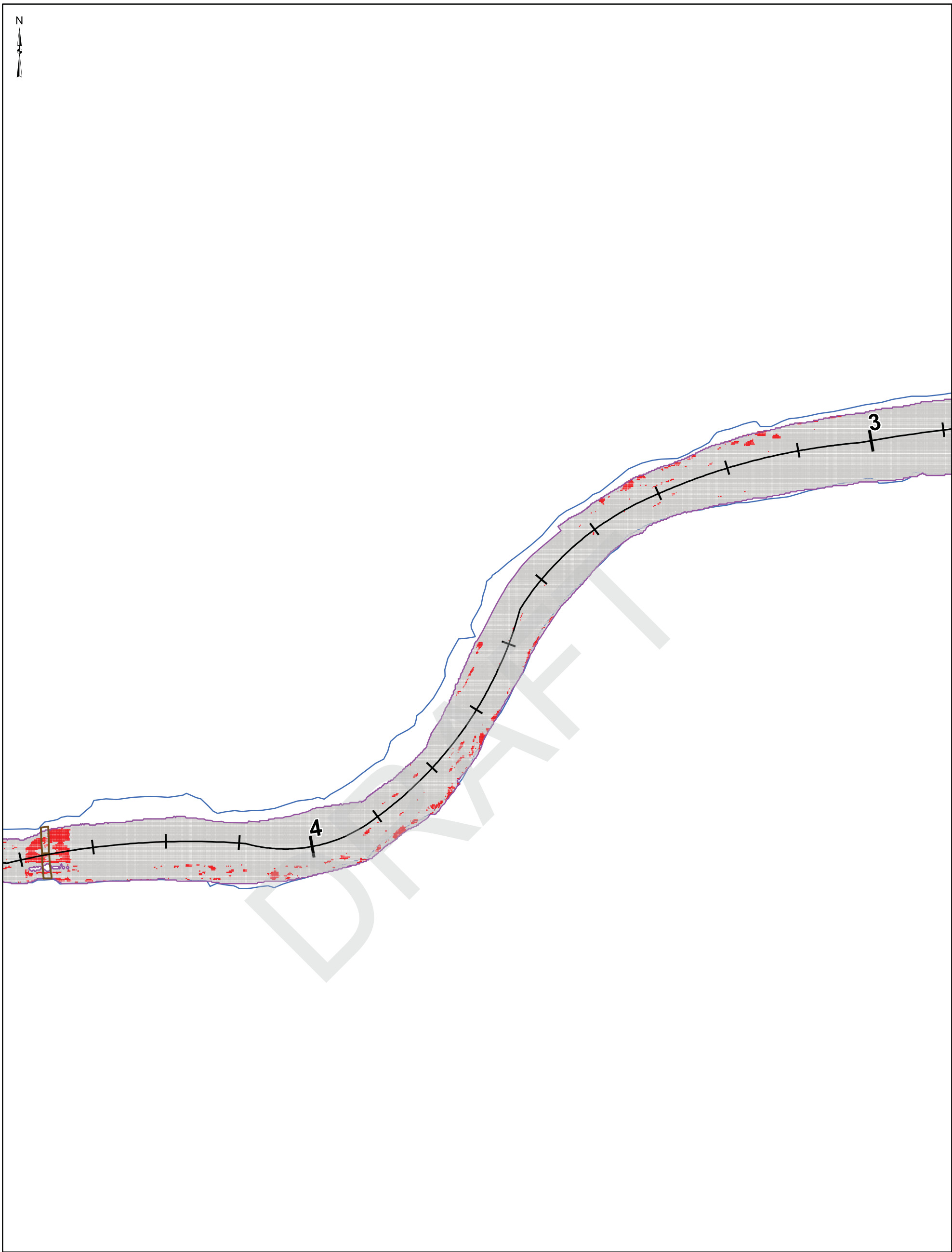
- Simulation Grid Extent
- Shoreline as defined by the NJDEP
- Bridges

0 250 500 1,000
Feet



Conditional Simulation Validation Results
Distribution of False Positives
Prediction of 6 inches of Erosion
Lower Passaic River Restoration Project

Figure 28b
2010



Legend

Probability of Occurrence
of at Least 6-inch Erosional Event

- < 0.5
- >= 0.5

- Simulation Grid Extent
- Shoreline as defined by the NJDEP
- Bridges

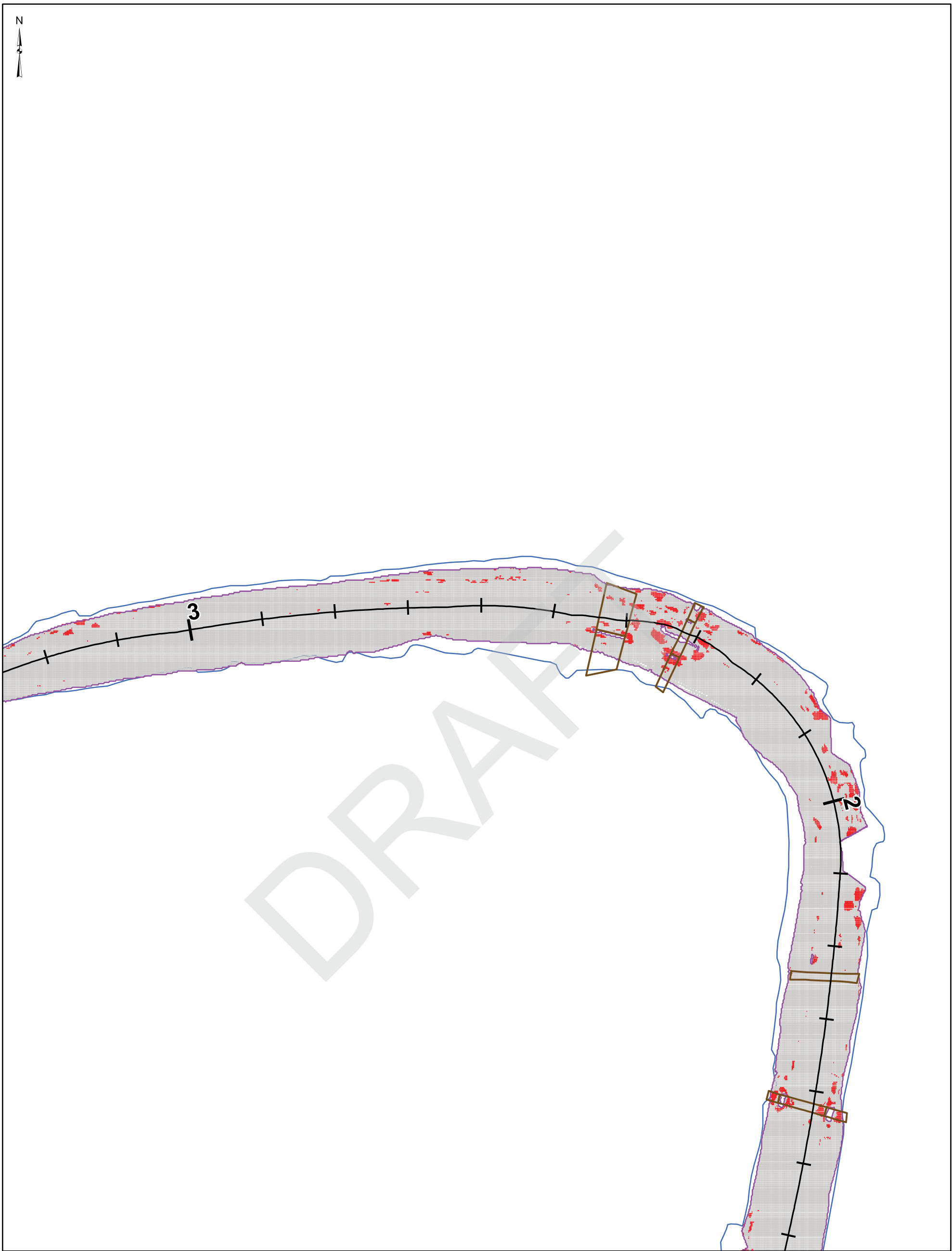
0 250 500 1,000 Feet



Conditional Simulation Validation Results
Distribution of False Positives
Prediction of 6 inches of Erosion
Lower Passaic River Restoration Project

Figure 28c
2010

P:\0285924\Mapping\CSM_MassBalance\bathy_95Transect_simulation_2007comparison.mxd



0 250 500 1,000 Feet

Legend

Probability of Occurrence
of at Least 6-inch Erosional Event

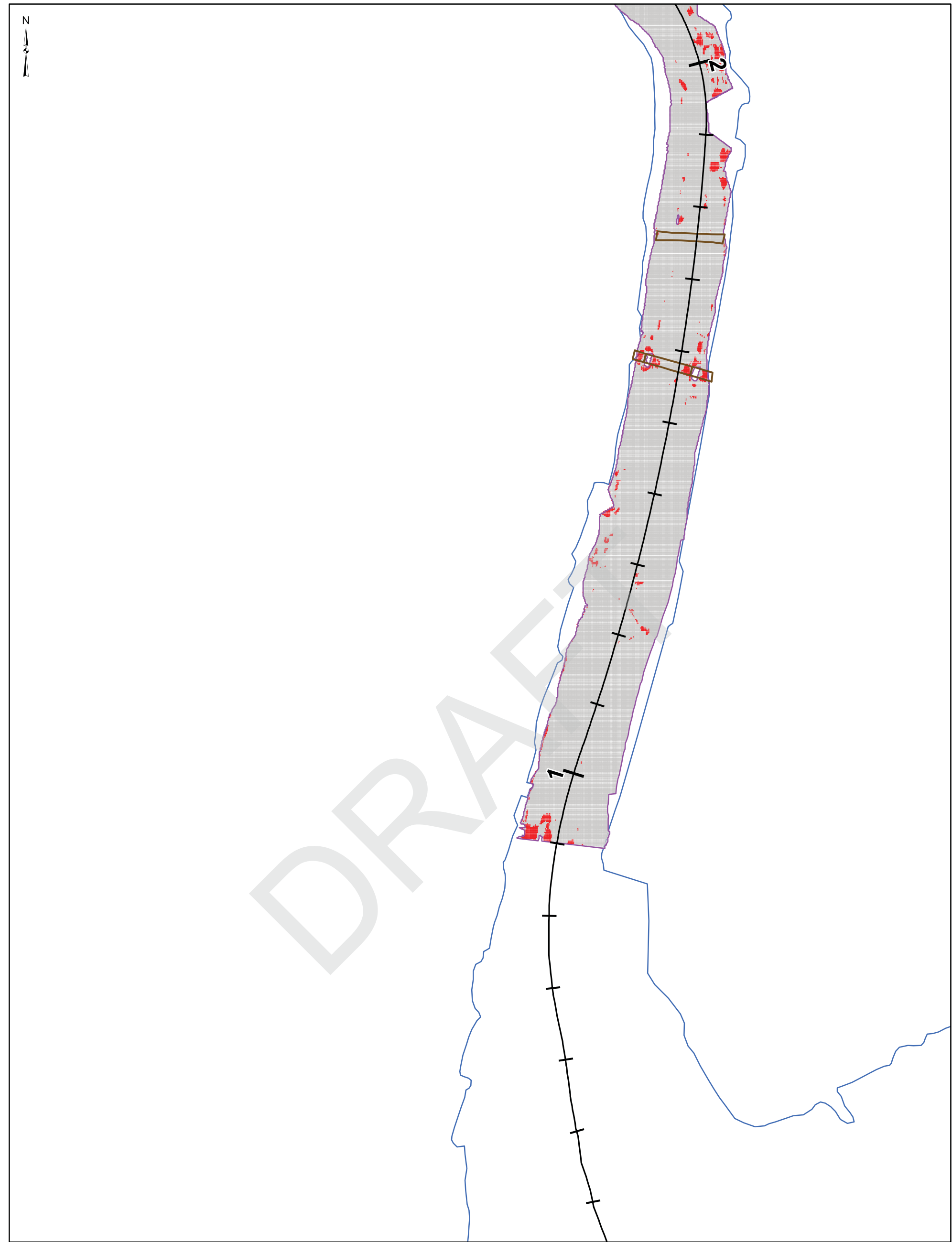
- < 0.5
- ≥ 0.5

- Simulation Grid Extent
- Shoreline as defined by the NJDEP
- Bridges



Conditional Simulation Validation Results
Distribution of False Positives
Prediction of 6 inches of Erosion
Lower Passaic River Restoration Project

Figure 28d
2010



Legend

Probability of Occurrence of at Least 6-inch Erosional Event

- < 0.5
- >= 0.5

- Simulation Grid Extent
- Shoreline as defined by the NJDEP
- Bridges



Figure 29: Segments of the Passaic River where 2008 and 2007 multibeam bathymetry data were compared based on average depth in a 3 ft by 3 ft grid spacing.

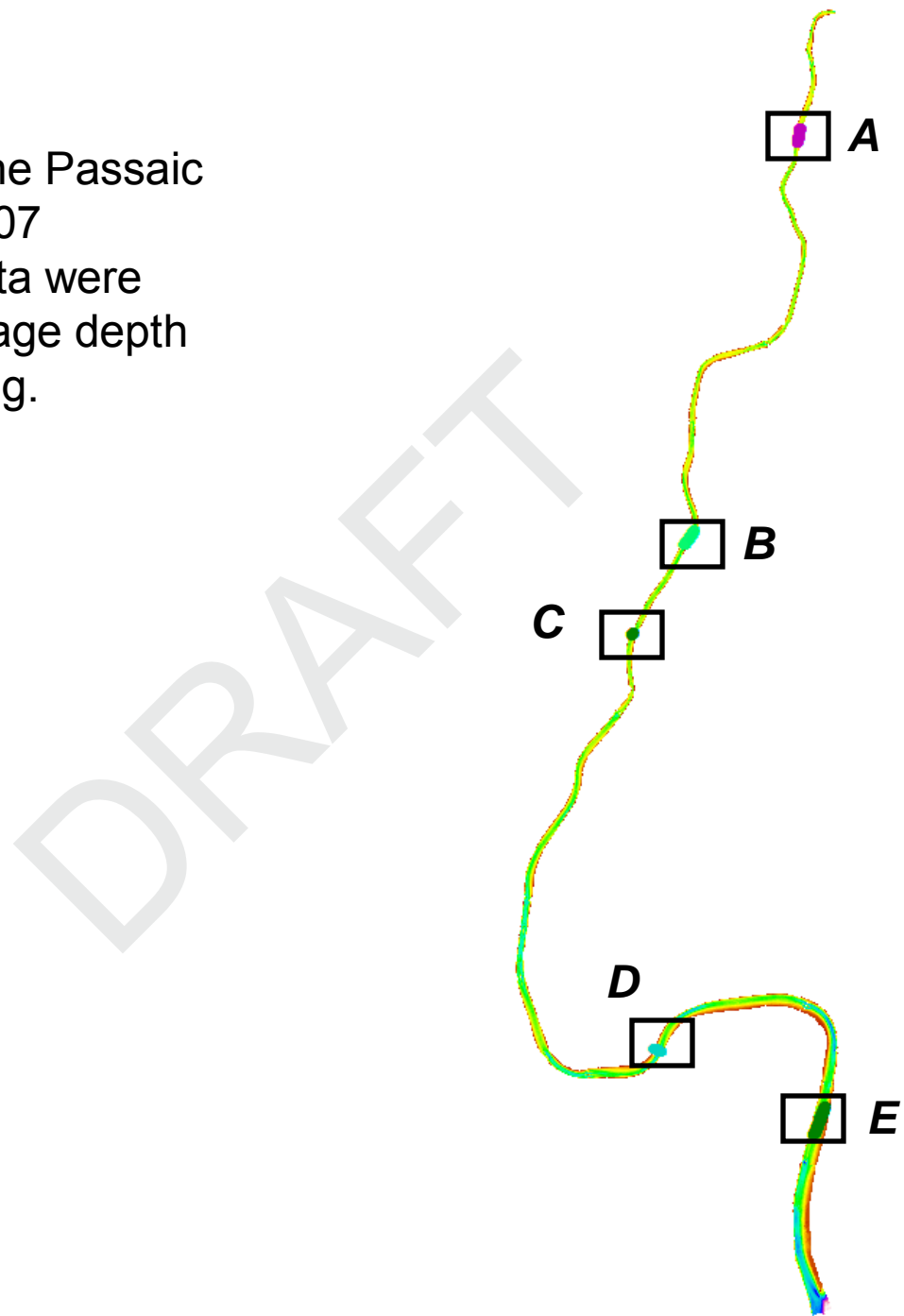
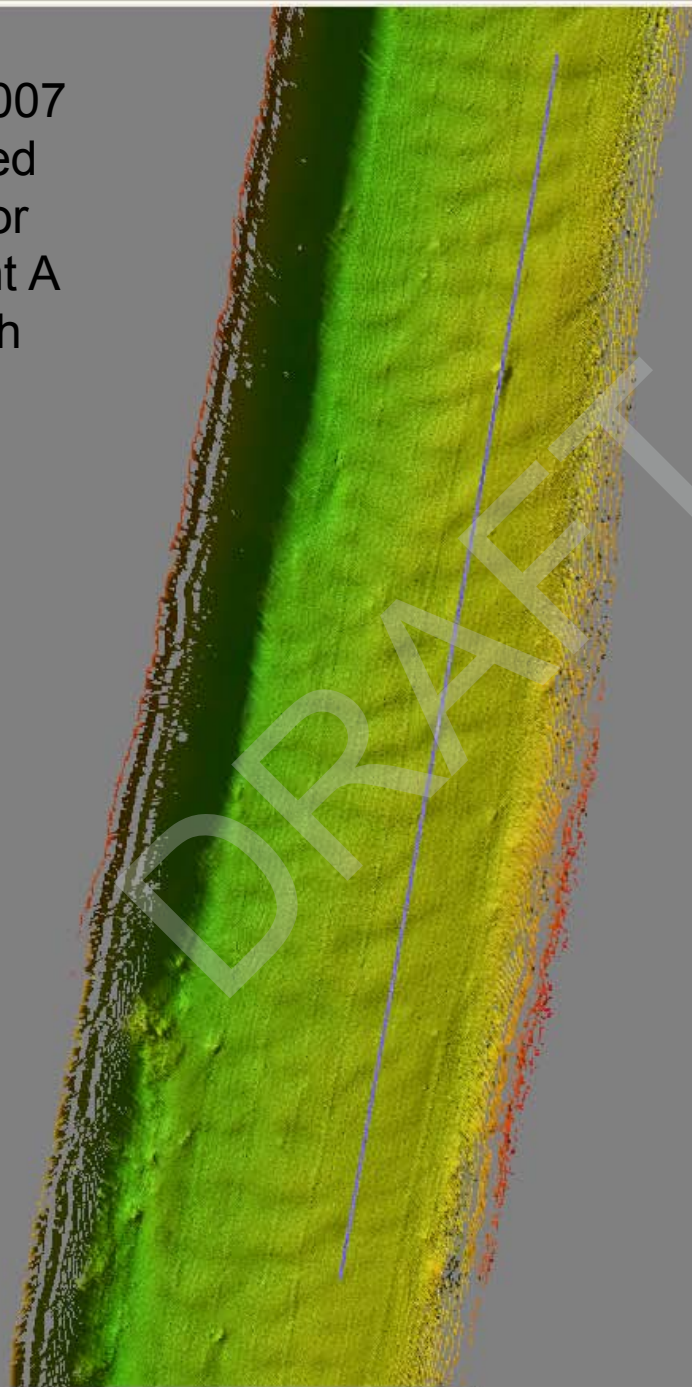
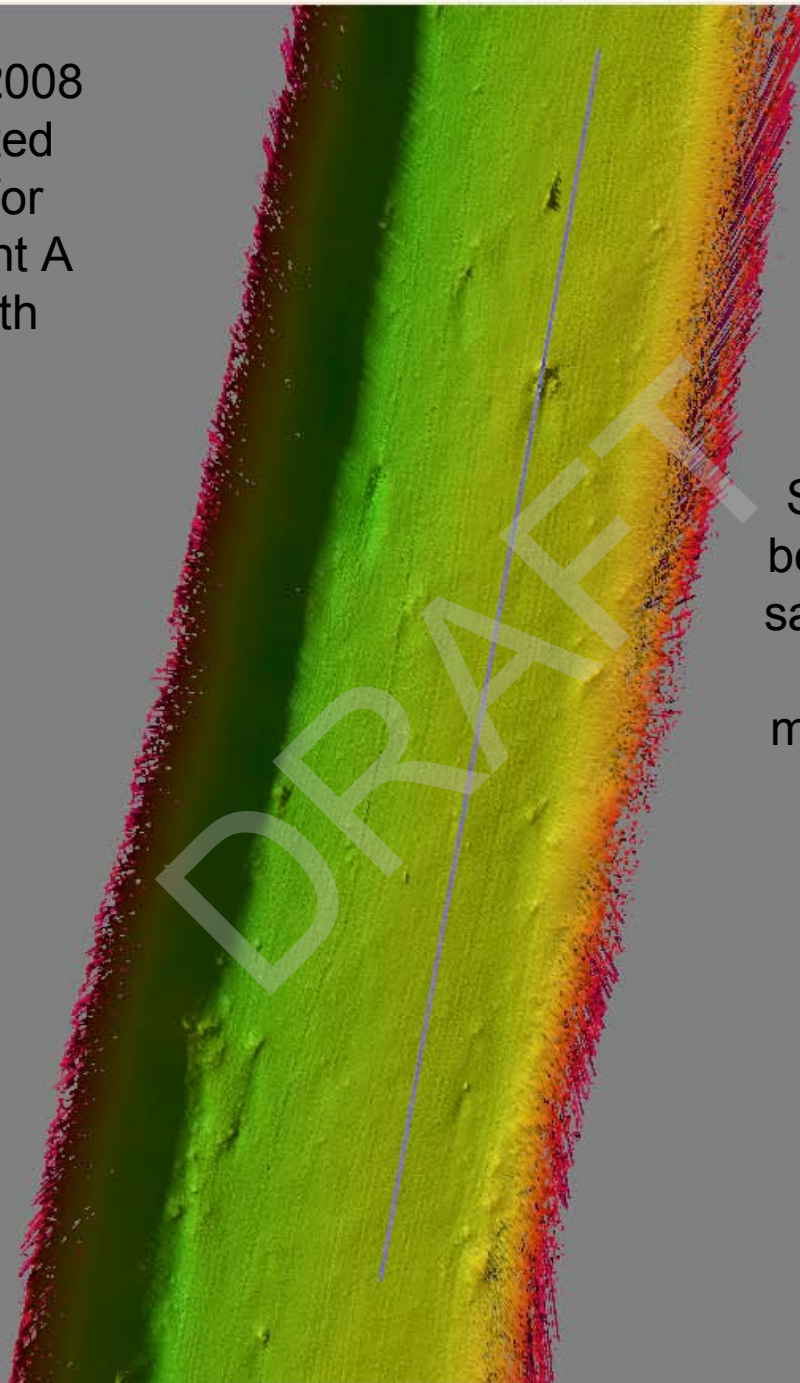


Figure 30a: 2007
Sun-illuminated
Bathymetry for
River Segment A
(RM13.6) with
transect



Sand waves
with some
mounds

Figure 30b: 2008
Sun-illuminated
bathymetry for
River Segment A
(RM13.6) with
transect



Smoother
bed with no
sand waves
but with
many more
mounds

N

S

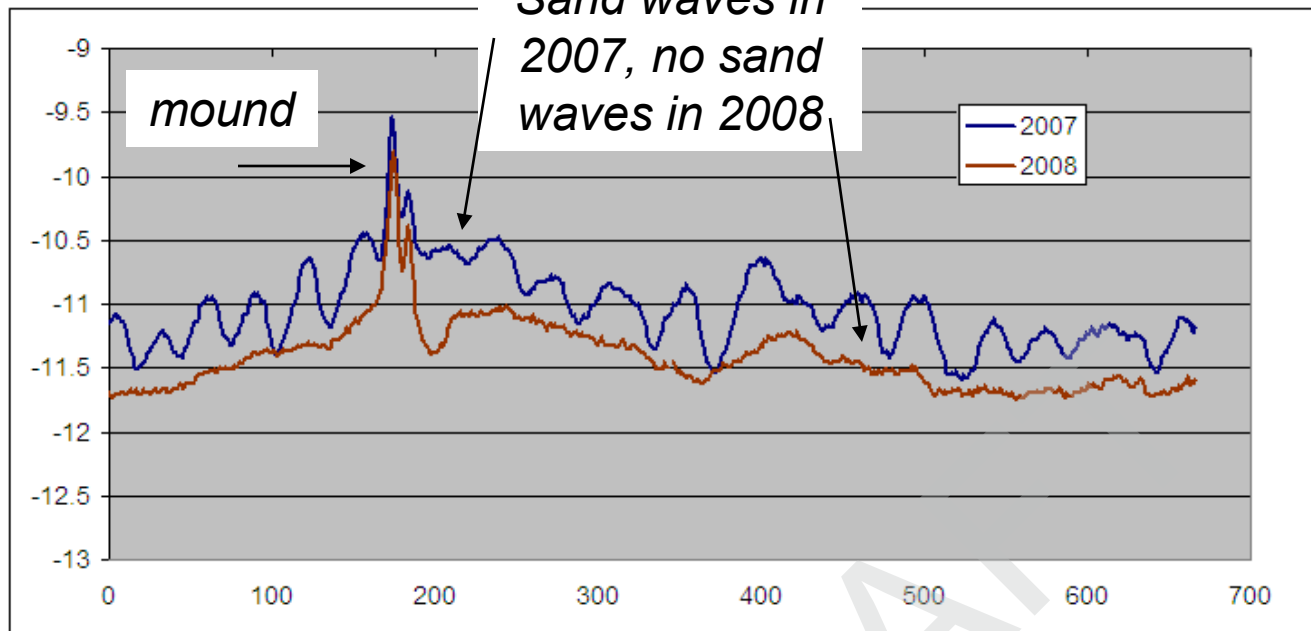
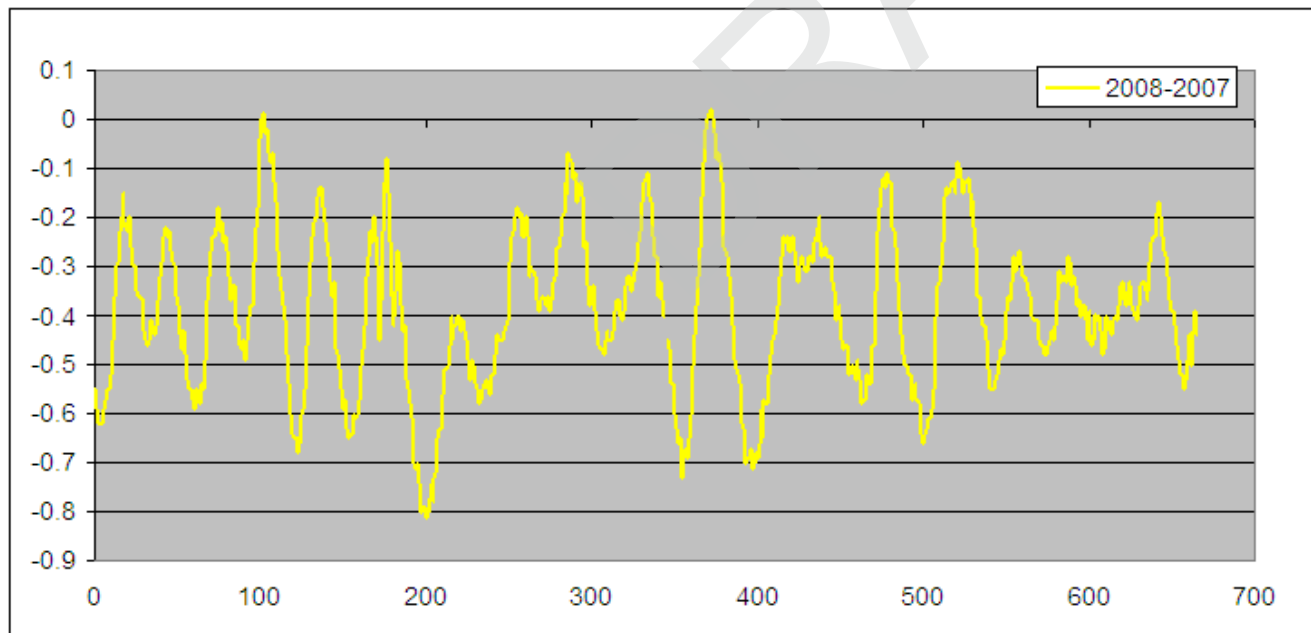


Figure 30c:

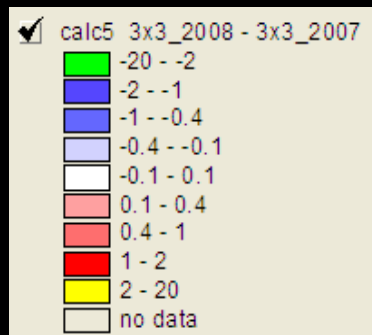
River Segment A
(RM13.6) Transect
bathymetry in 2007
and 2008 and
change
(2008-2007).

Depths (x-axis) and
Distances (y-axis) in
Feet



A

Figure 30d: Difference between 2007 and 2008 multibeam bathymetry (feet; negative deeper in 2008) for River Segment A (RM13.6) with transect location



*sand waves
were eroded
between 2007
and 2008
surveys*

Figure 31a: 2007
Sun-illuminated
bathymetry for
River Segment
B (RM9.75) with
transect

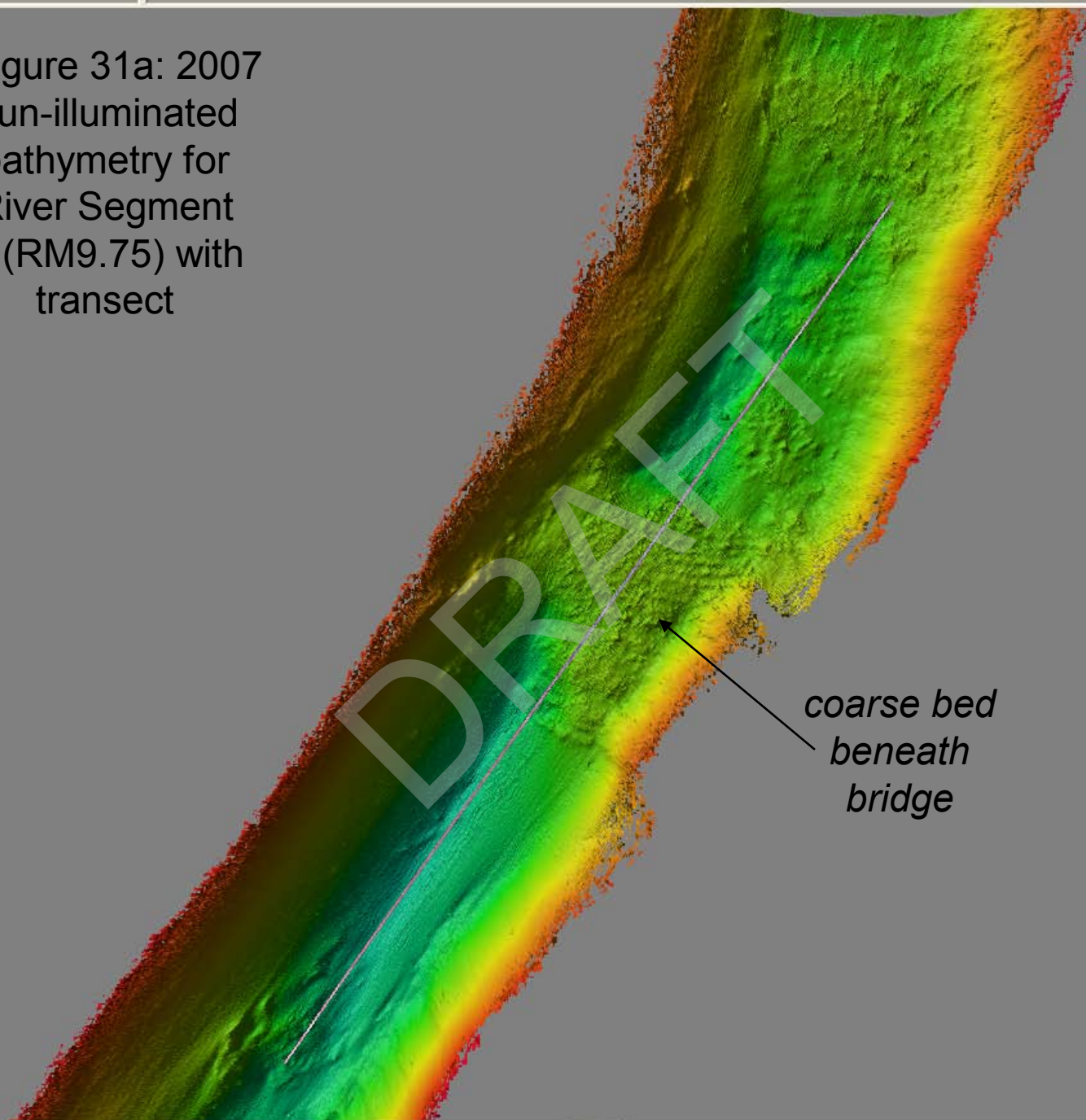
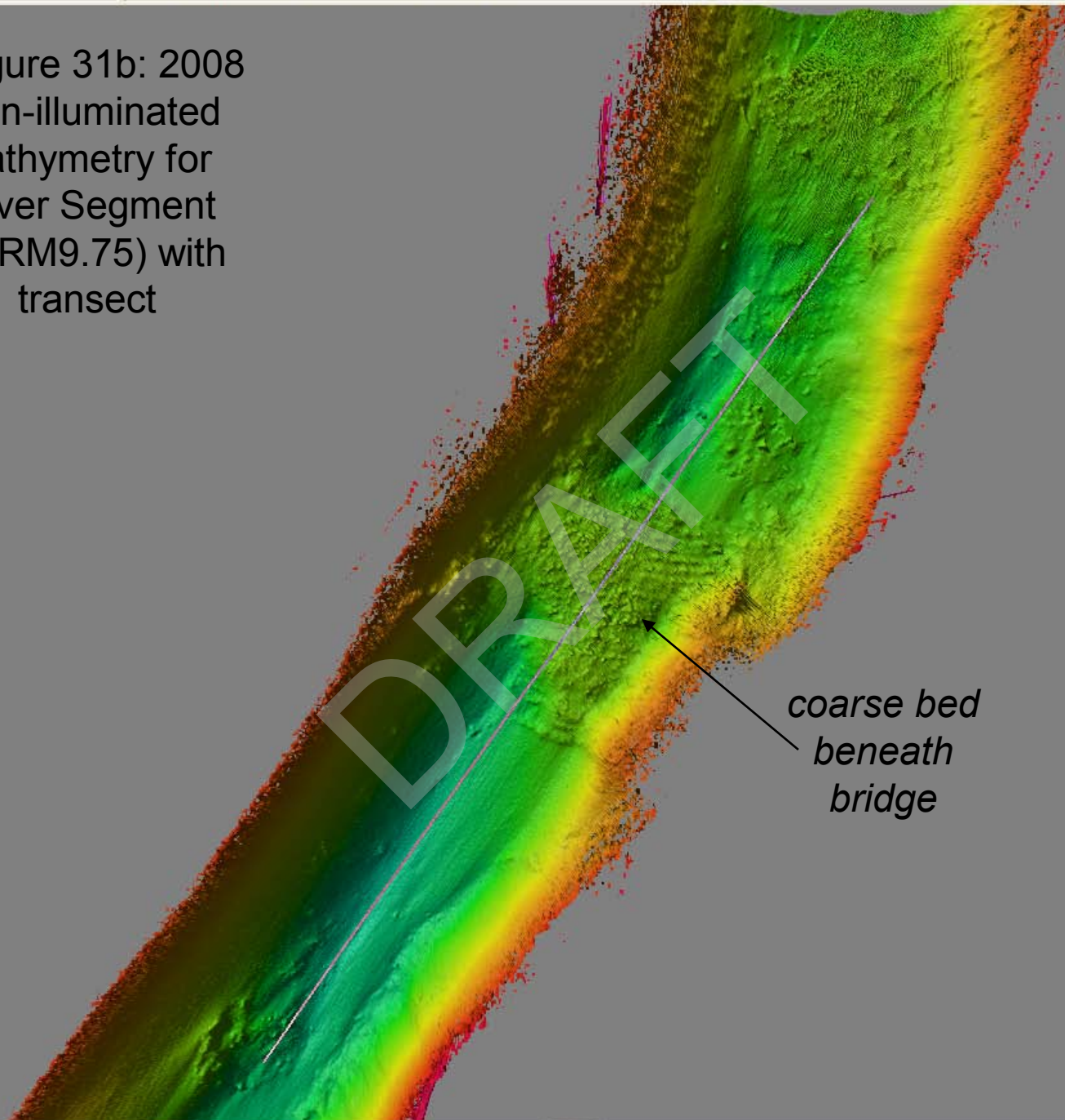


Figure 31b: 2008
Sun-illuminated
bathymetry for
River Segment
B (RM9.75) with
transect



N

S

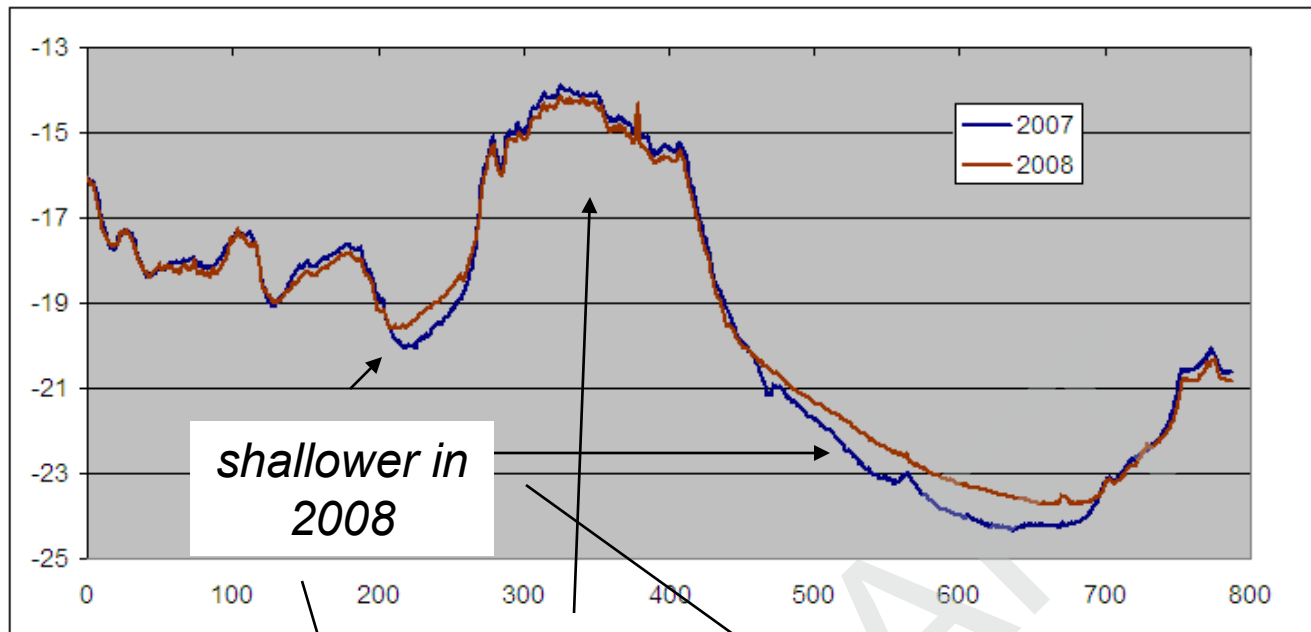
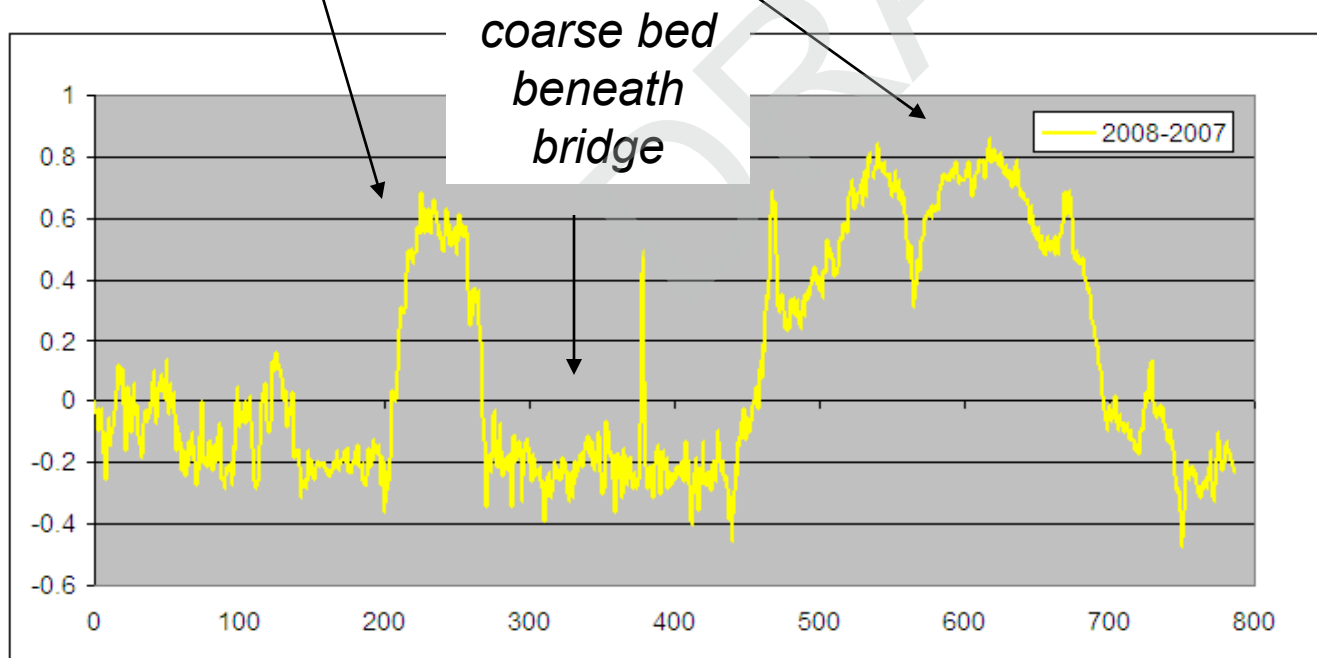


Figure 31c: River Segment B (RM9.75) Transect bathymetry in 2007 and 2008 and change (2008-2007).

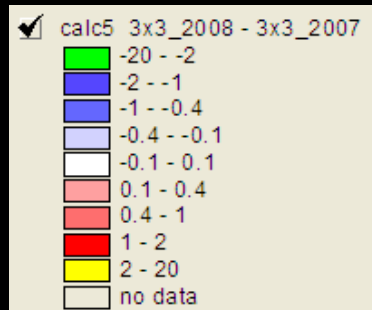
Depths (x-axis) and Distances (y-axis) in Feet



Coarse bed beneath bridge is about 0.2 feet deeper in 2008 than in 2007. It is likely that there was no erosion beneath bridge.

B

Figure 31d: Difference between 2007 and 2008 multibeam bathymetry (feet; negative deeper in 2008) for River Segment B (RM9.75) with transect location



*depressions on
either side of
bridge
shallower in
2008*

Figure 32a: 2007
Sun-illuminated
bathymetry for
River Segment
C (RM8.85)
with transect

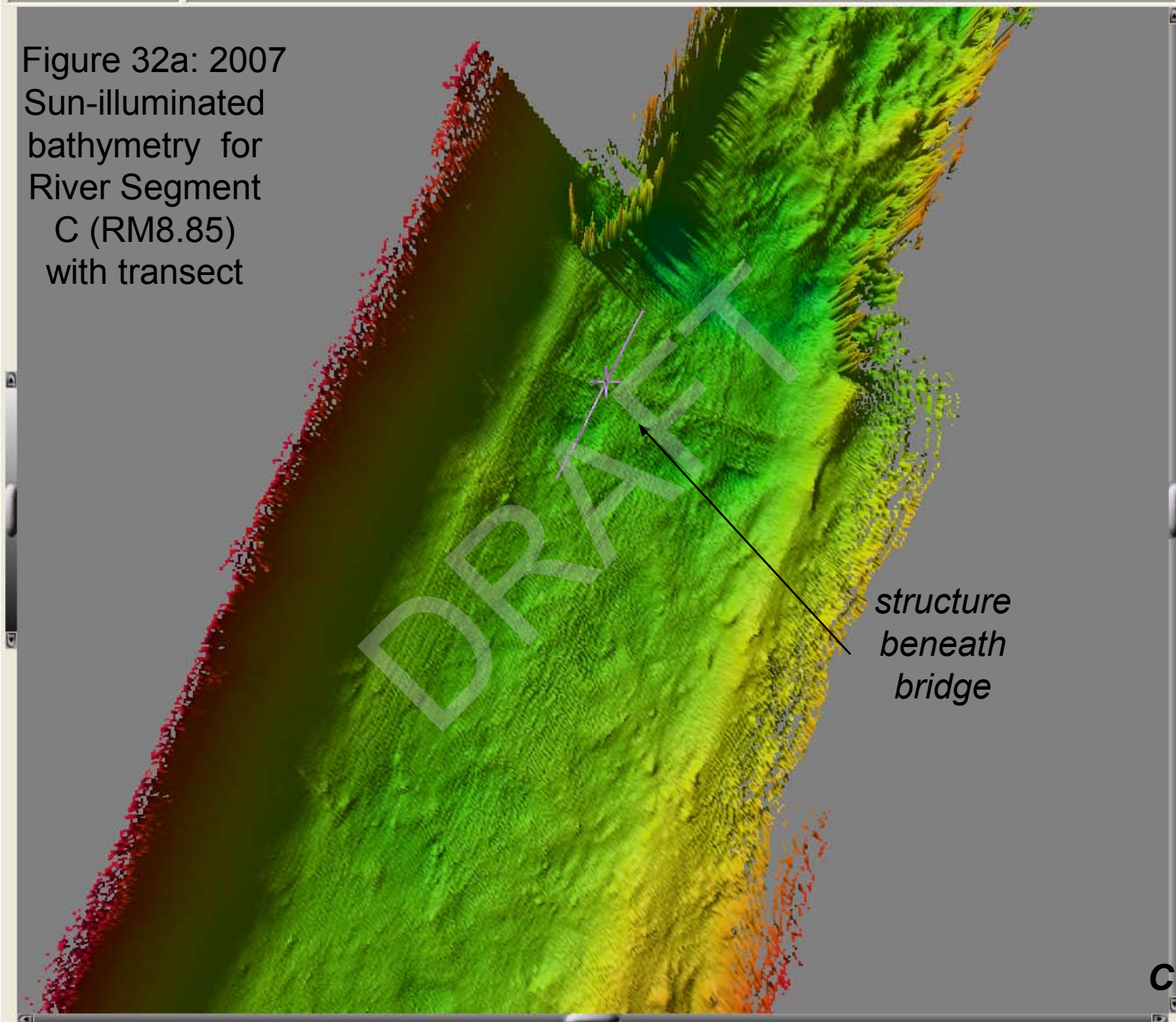
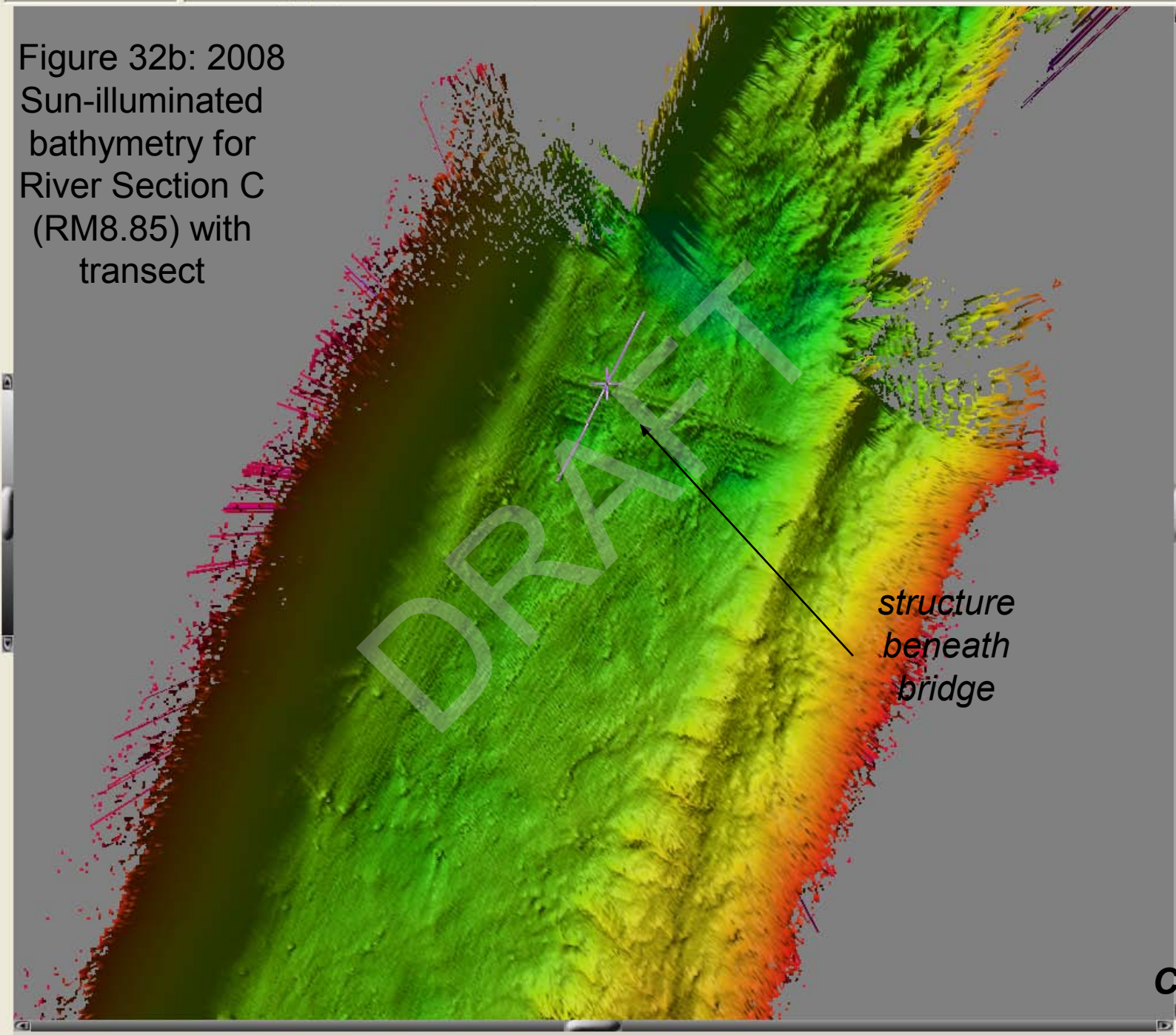


Figure 32b: 2008
Sun-illuminated
bathymetry for
River Section C
(RM8.85) with
transect



N

S

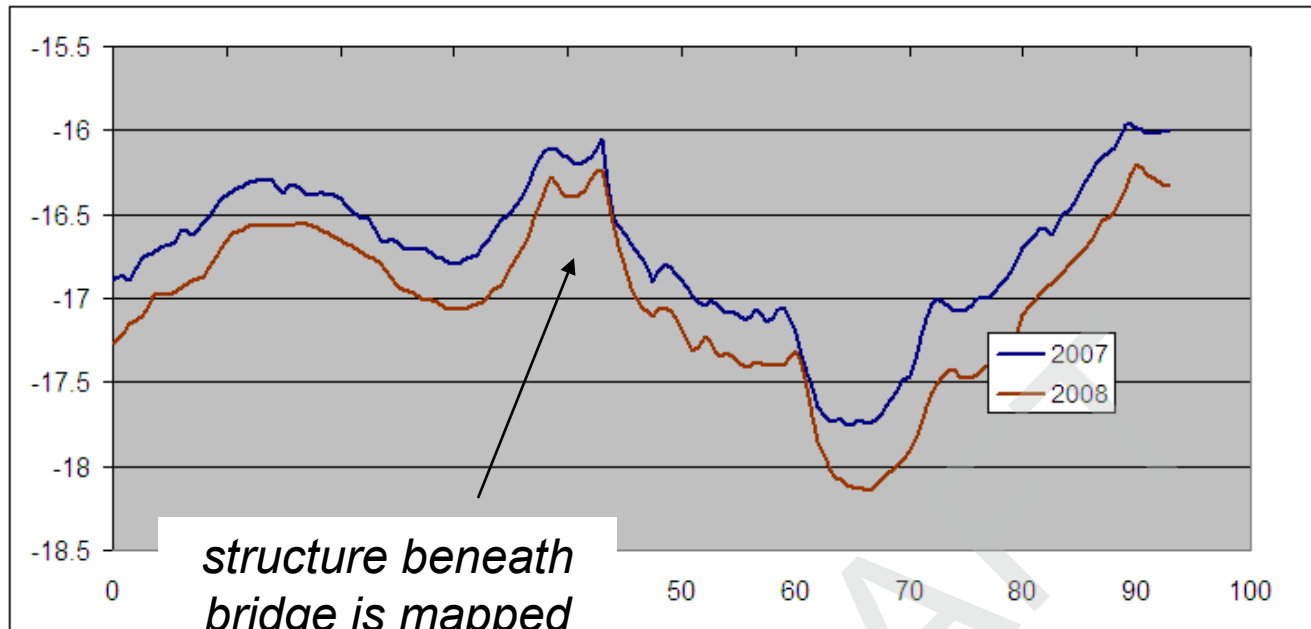
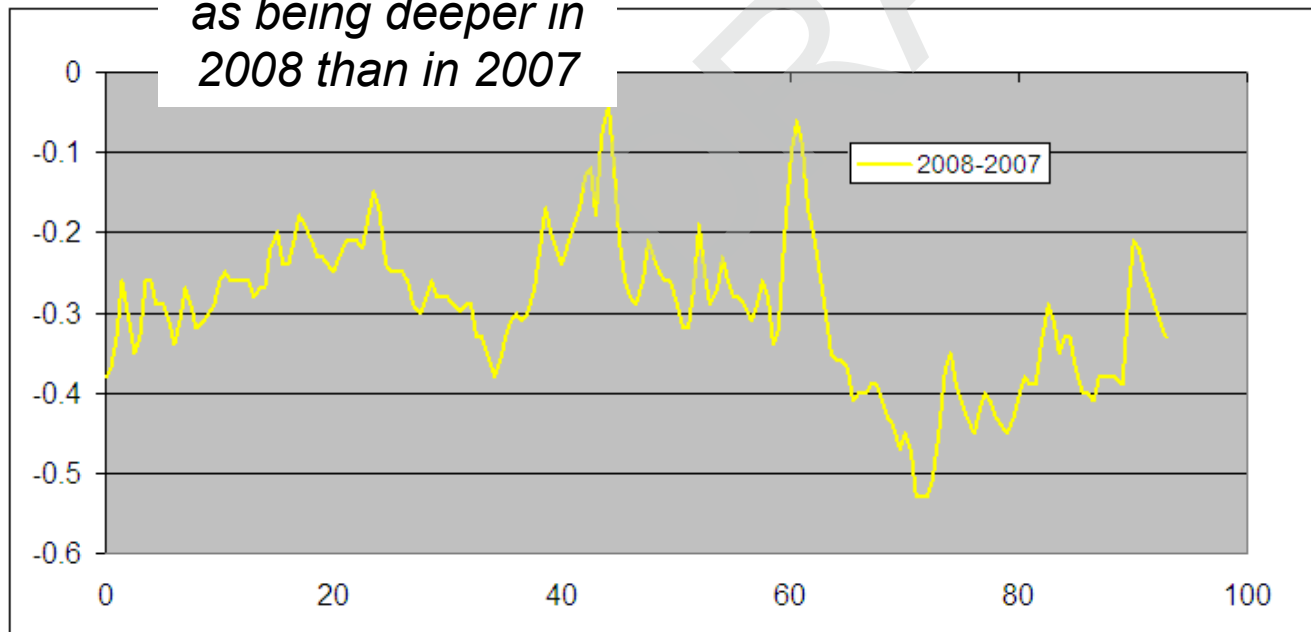


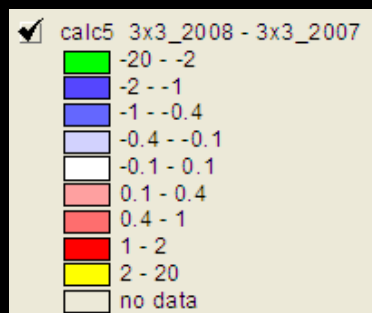
Figure 32c: River Segment C (RM8.85) Transect bathymetry in 2007 and 2008 and change (2008-2007).

Depths (x-axis) and Distances (y-axis) in Feet



C

Figure 32d: Difference between 2007 and 2008 multibeam bathymetry (feet; negative deeper in 2008) for River Segment C (RM8.85) with transect location



*structure
beneath
bridge*

Figure 33a:
2007 Sun-
illuminated
bathymetry for
River Segment
D (RM4.05) with
transect

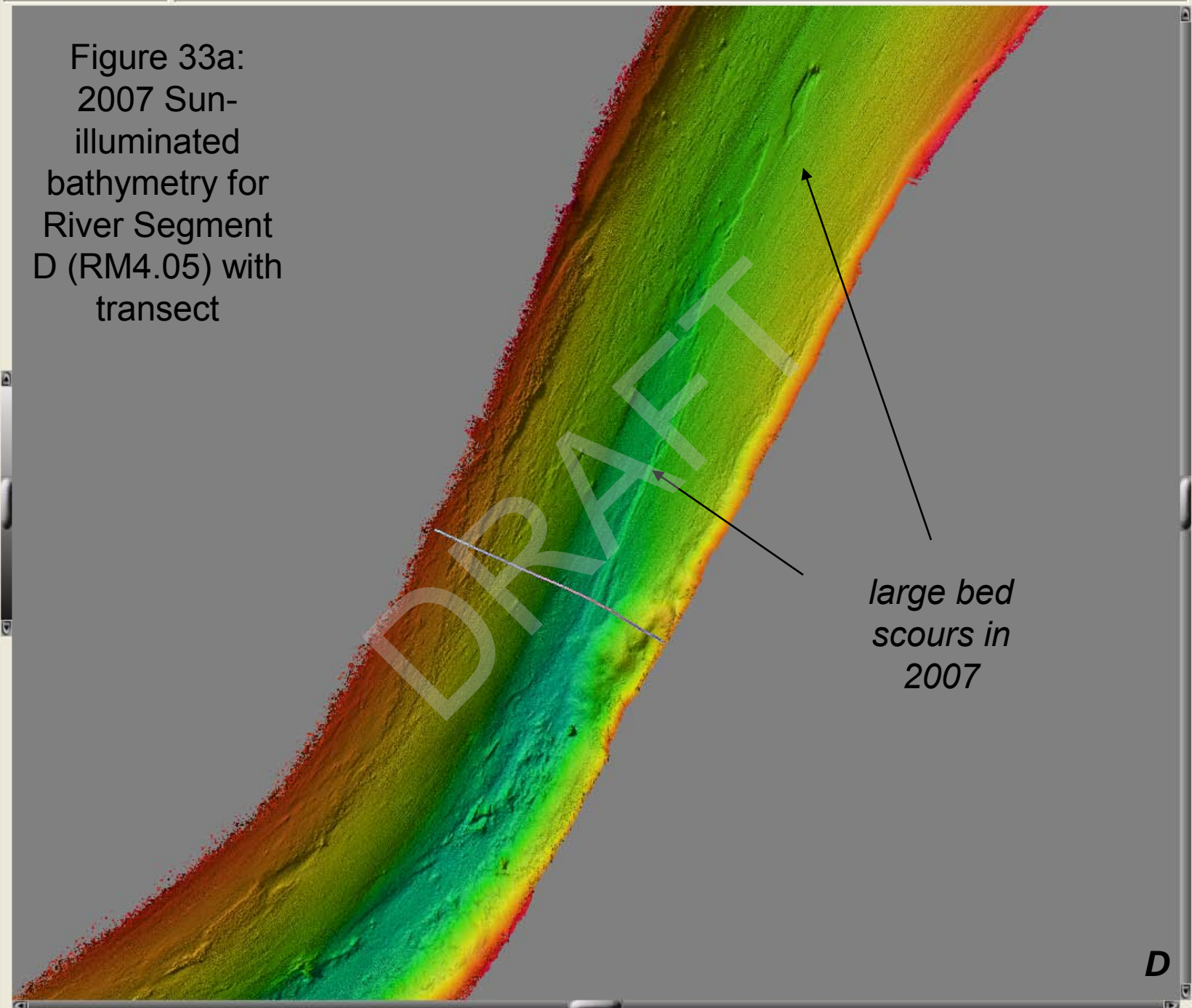


Figure 33b: 2008
Sun-illuminated
bathymetry for
River Segment D
(RM4.05) with
transect

*erosional
areas in
2008*

*filled scours
in 2008*

D

NW

SE

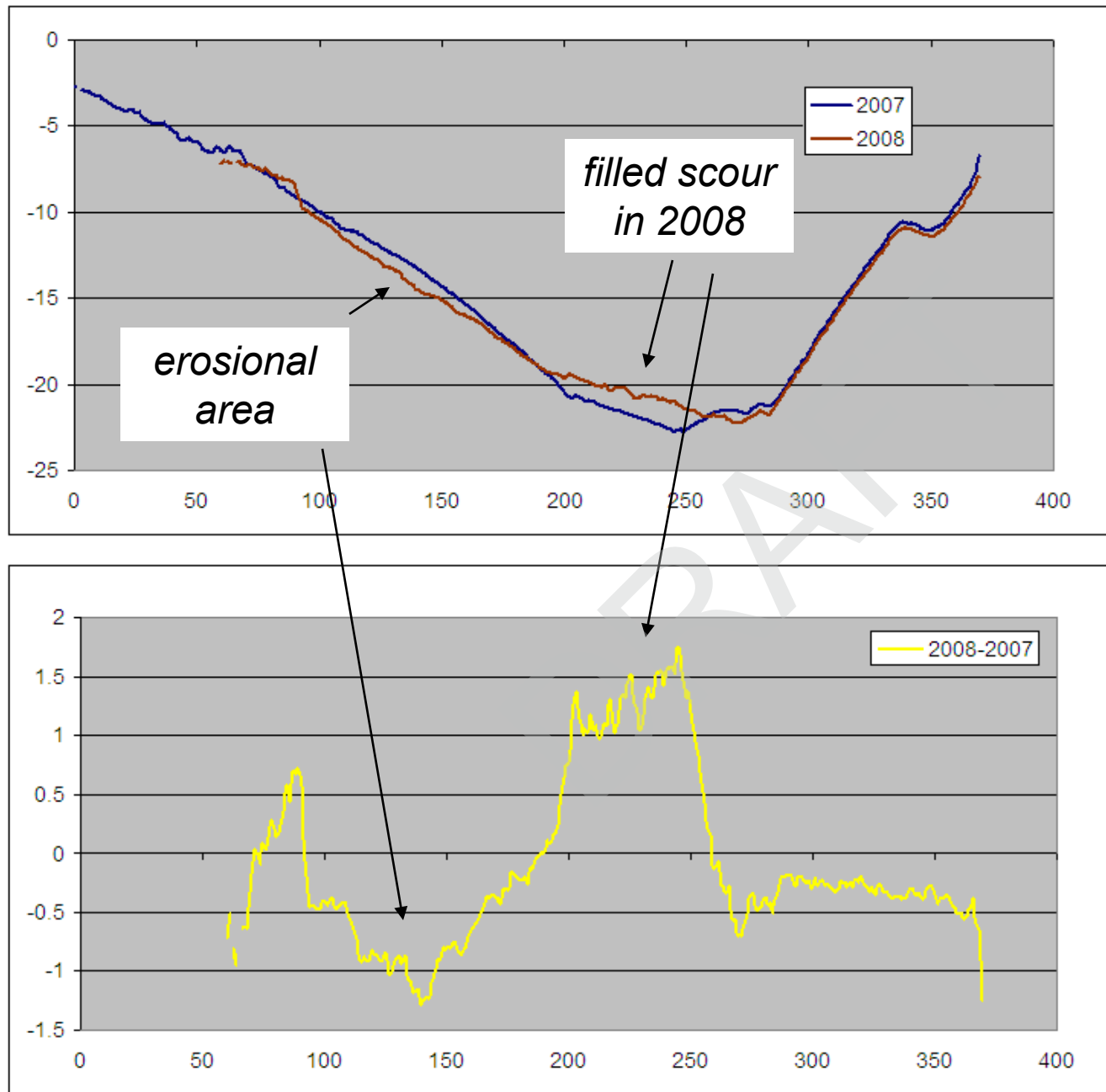
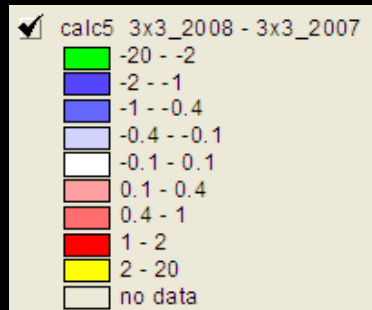
**D**

Figure 33d: Difference between 2007 and 2008 multibeam bathymetry (feet; negative deeper in 2008) for River Segment D (RM4.05) with transect location



erosional area

*filled
scours in
2008*

Figure 34a:
2007 Sun-
illuminated
bathymetry for
River Section E
(RM1.6) with
transect

generally
smooth with
some local
depressions

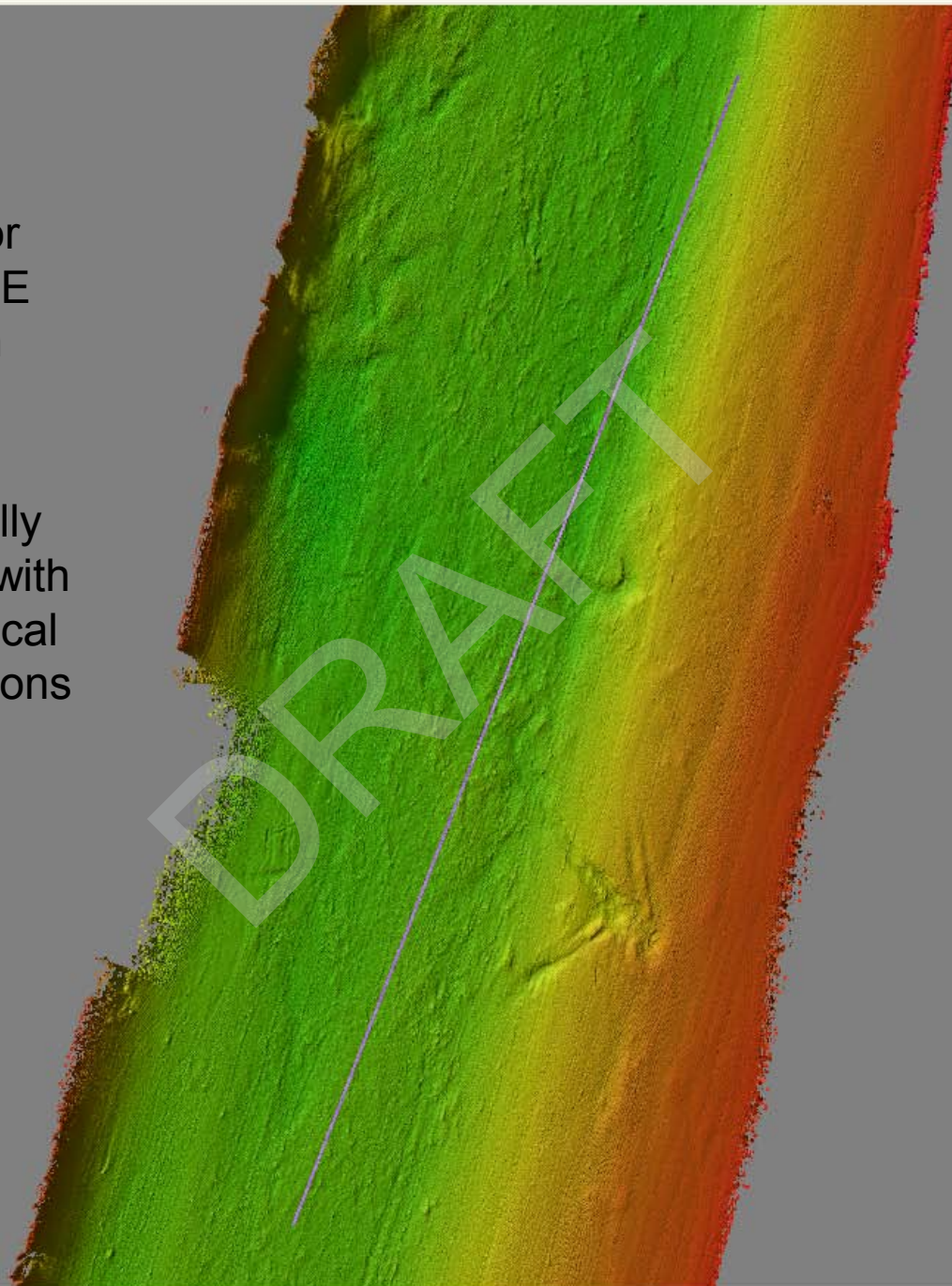
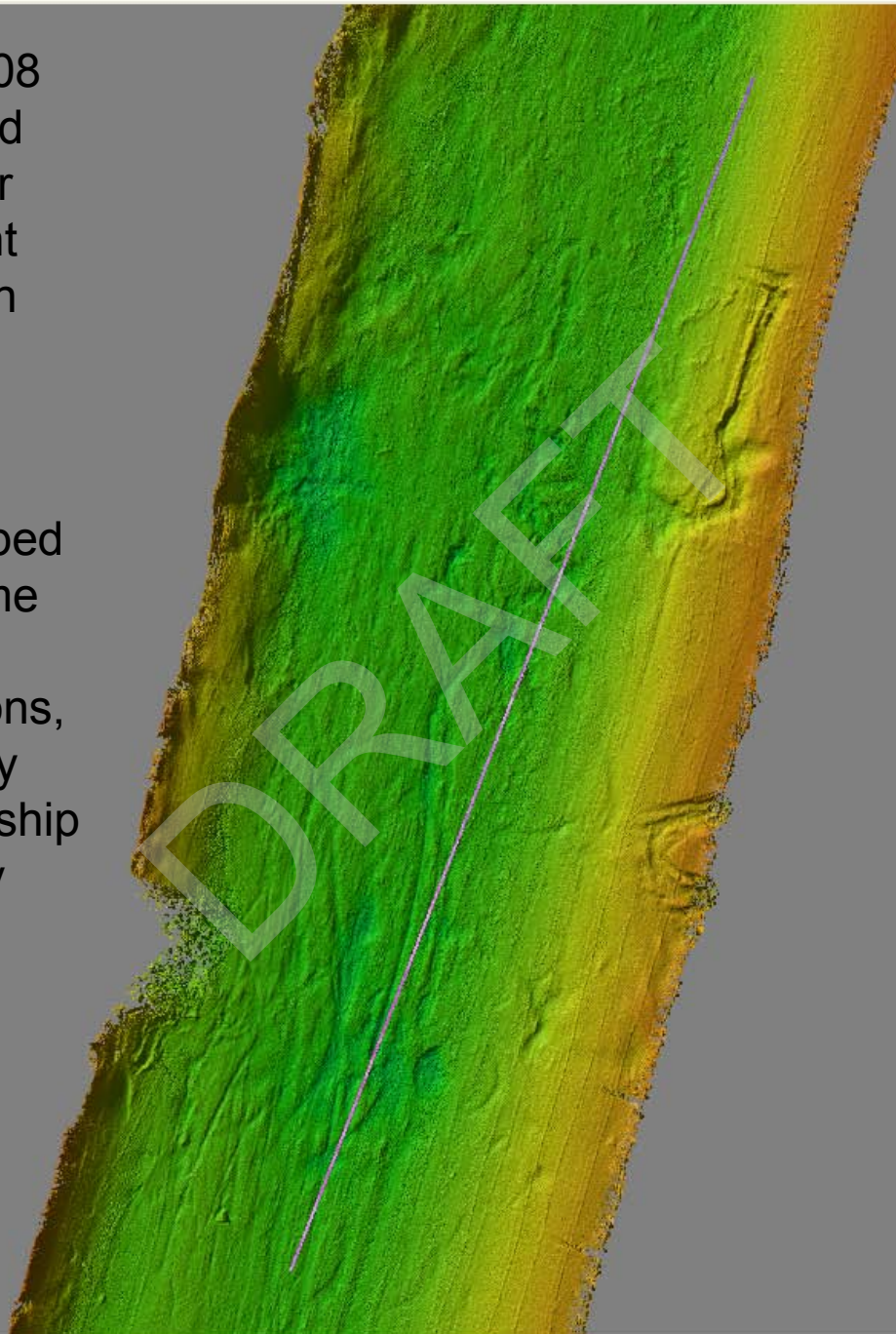


Figure 34b: 2008
Sun-illuminated
bathymetry for
River Segment
E (RM1.6) with
transect

irregular bed
with some
local
depressions,
possibly
related to ship
activity



N

S

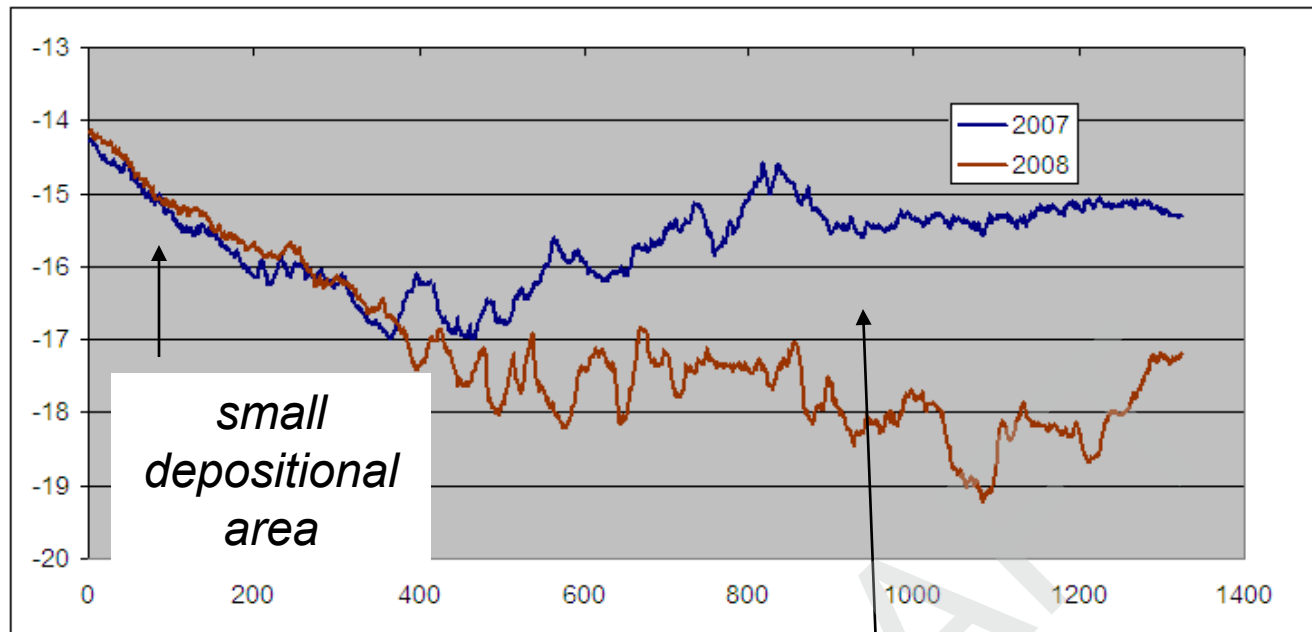
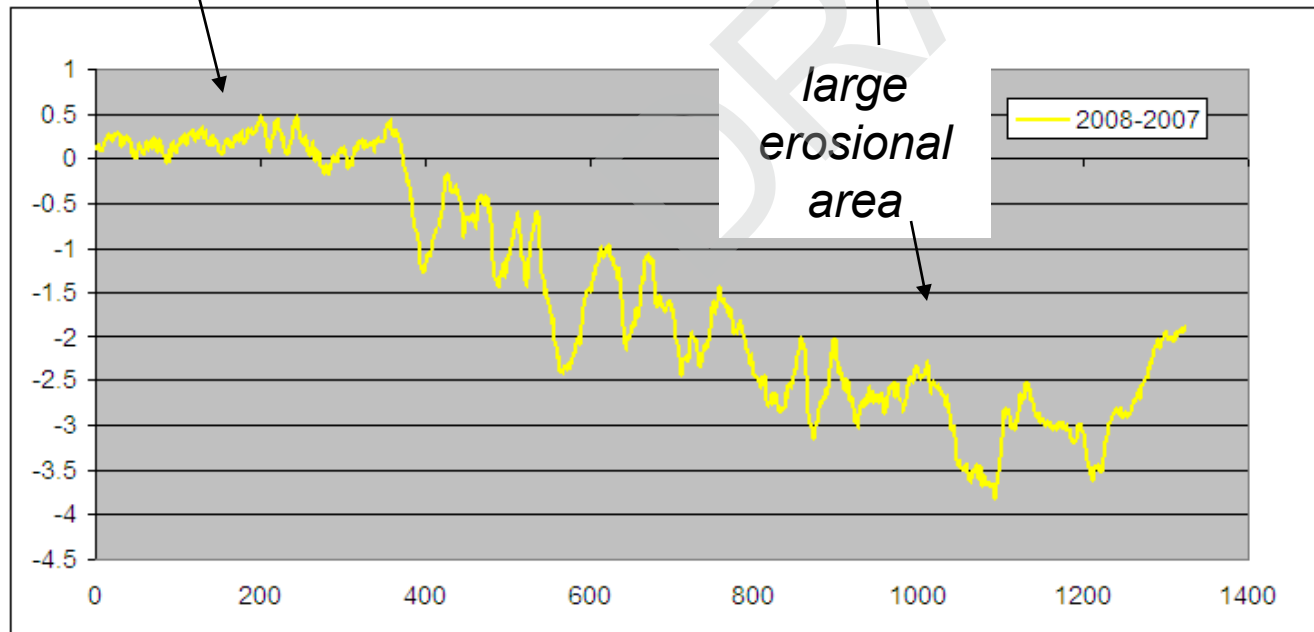


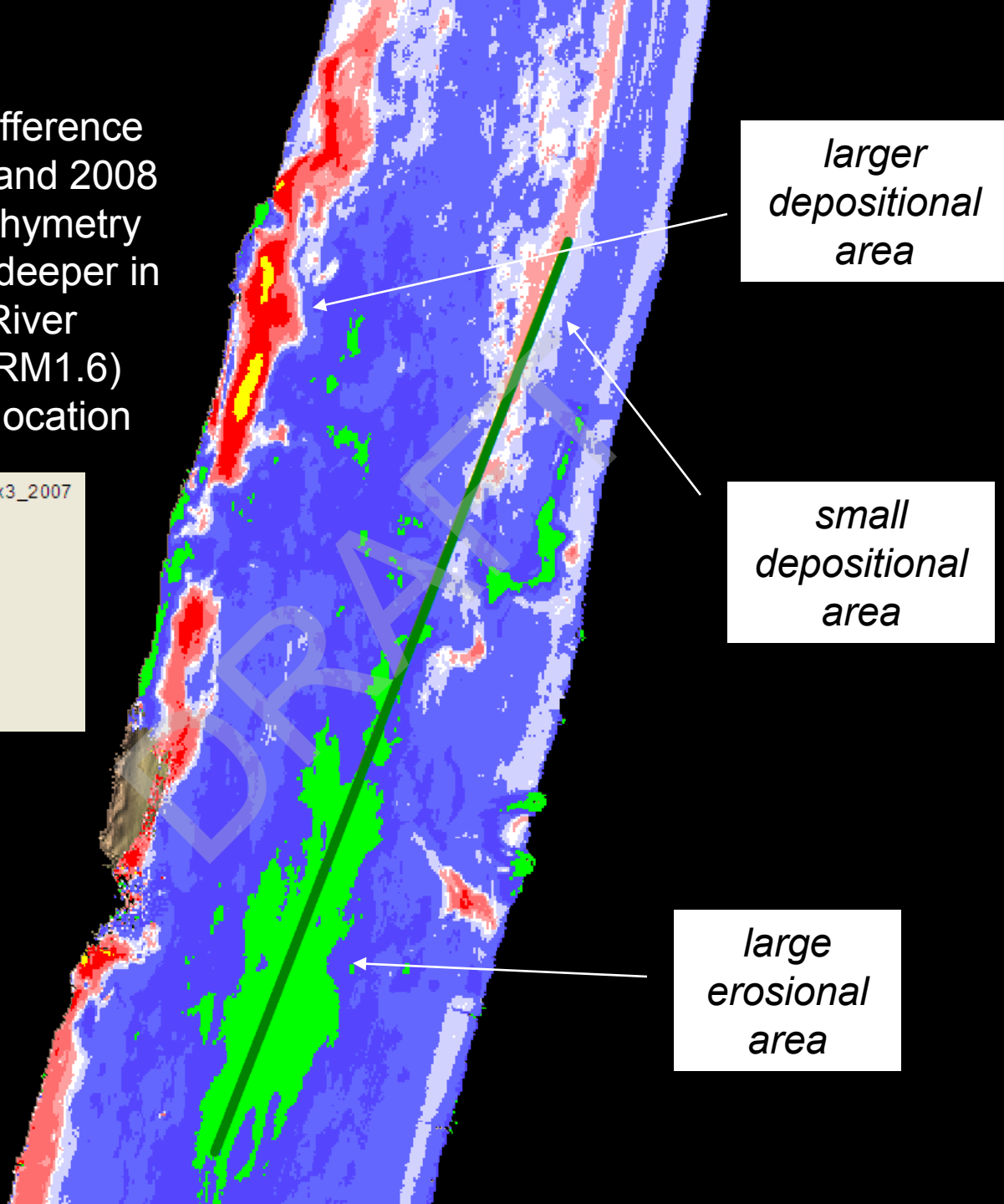
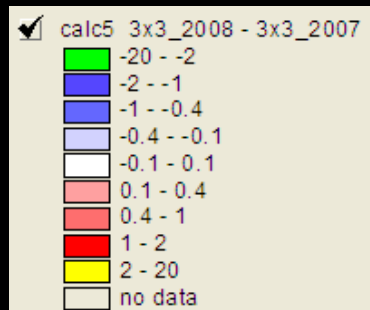
Figure 34c: River Segment E (RM1.6) Transect bathymetry in 2007 and 2008 and change (2008-2007).

Depths (x-axis) and Distances (y-axis) in Feet



E

Figure 34d: Difference between 2007 and 2008 multibeam bathymetry (feet; negative deeper in 2008) for River Segment E (RM1.6) with transect location



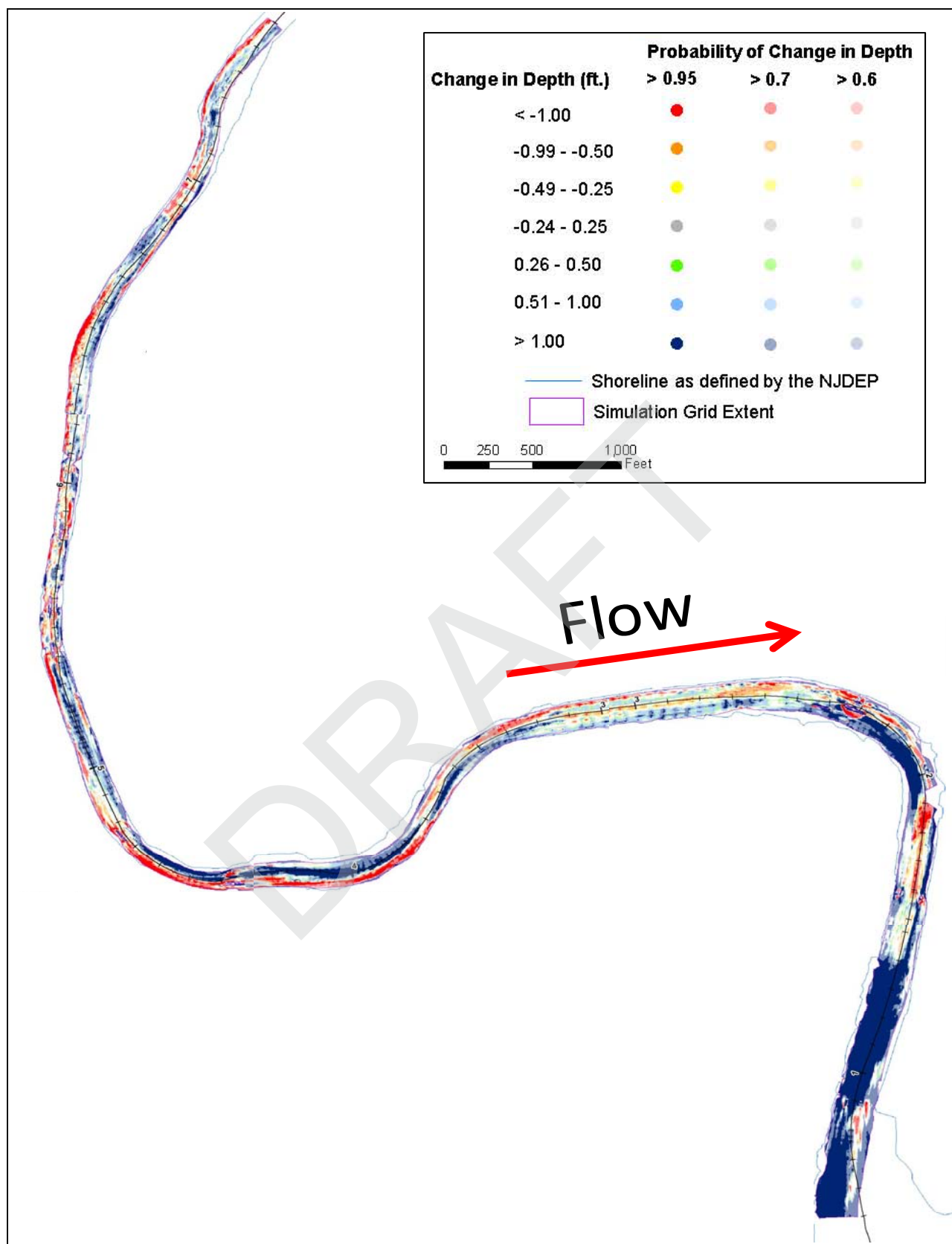


Figure 35. Net elevation change from 1989 through 2007.